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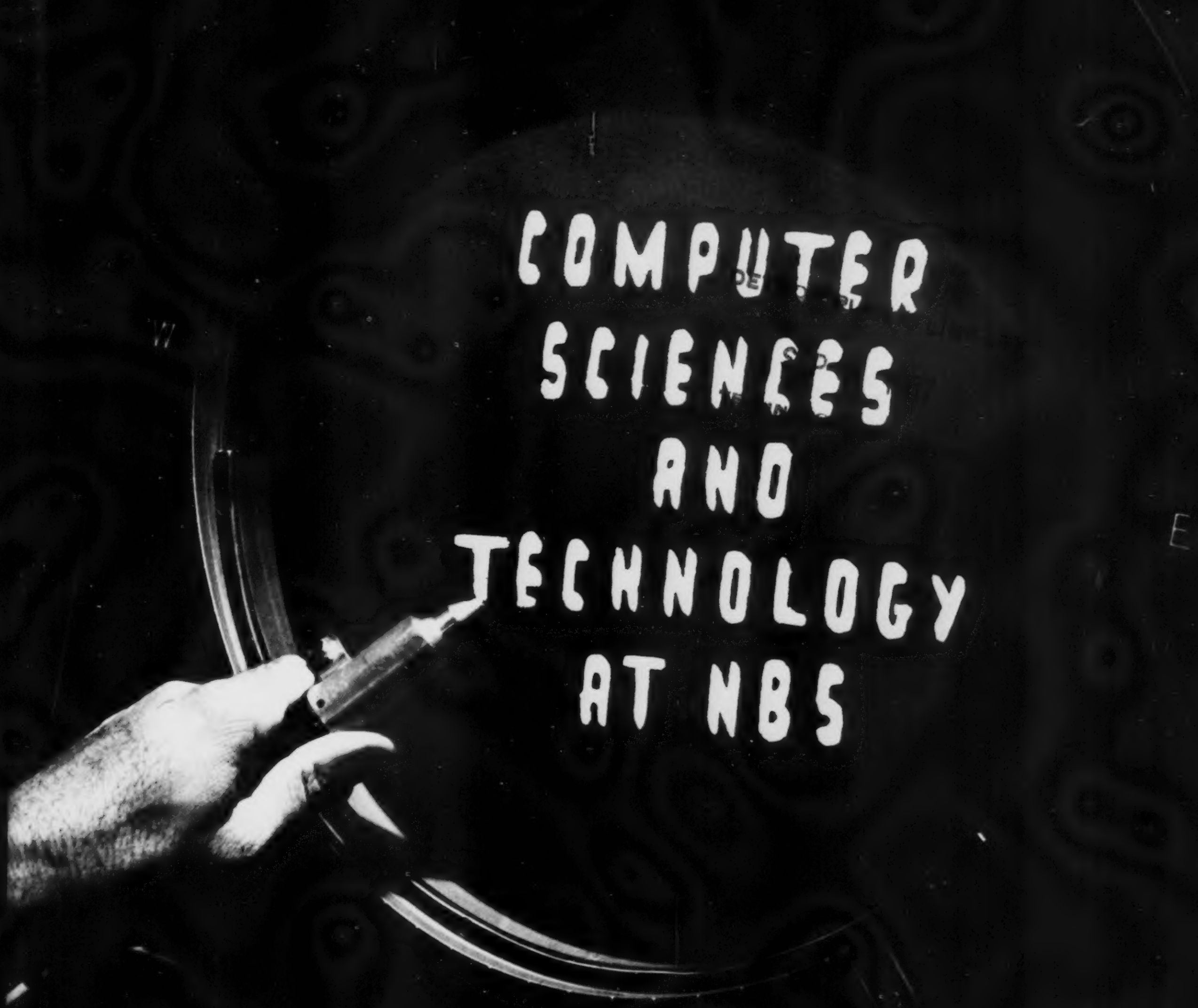

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

Technical News Bulletin

AUGUST 1967/VOL. 51, NO. 8/ISSUED MONTHLY

CONTENTS

COVER

The subject of this Special Issue is written on the cathode ray tube of MAGIC (Machine for Automatic Graphics Interface to a Computer), an NBS-developed research tool designed to facilitate man's two-way communication with computers. (See page 182.)

U.S. DEPARTMENT OF COMMERCE
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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized into three institutes—
- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of all three institutes.

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NBS UNDERTAKES BROADER PROGRAM IN COMPUTER SCIENCES AND TECHNOLOGY

■ For more than 20 years the National Bureau of Standards has played a key role in the development of methods and techniques for automatic data processing. This role has now been greatly expanded with the establishment of the Center for Computer Sciences and Technology within the NBS Institute for Applied Technology. Since the Center was set up in September 1965, it has organized and begun a broad program of standardization activities, applied research, and continuing consultative, advisory, and computing services for Federal agencies. In view of the importance of this program to the ADP community, both within and outside the Government, this special issue of the Technical News Bulletin has been planned to present a representative sampling of the Center's activities.

The primary impetus for the establishment of the Center was the Federal Government's concern with the rapidly growing cost of the computers used by Government agencies and their contractors. In 1965 this cost was estimated at $3 billion a year. In 1963, the Comptroller General of the United States had submitted 100 audit reports to the Congress reflecting his view of the need for better management of Federal Government use of computers. As a result, the Congress asked the President to arrange for a comprehensive study to find out what should be done to obtain better management of the utilization of computers by or for the Federal Government. One of the recommendations contained in the report which the President approved was:

> In order to improve the state-of-the-art and to provide a source of expertise to Government agencies we recommend legislation to provide specific authority and direction to the Secretary of Commerce to establish a centralized research center on computer sciences and technology and to provide advisory and consultative services to Government agencies on computer systems development and related scientific and technical problems.

The results of the study were given in a report [1] prepared by the Bureau of the Budget, which the President submitted to the Congress in March 1965. The Congress acted on the report (and the President's recommendation thereon) through passage of Public Law 89–306, approved October 30, 1965 (Brooks bill).

Under this Act, the Bureau of the Budget, the General Services Administration, and the Department of Commerce have each been given certain responsibilities for improving the procurement, utilization, and management of computers and related information systems in the Federal Government. To carry out these responsibilities, a unique three-agency program has been set up in which the Office of ADP Management, Bureau of the Budget, provides policy and planning guidance, the Federal Supply Service of GSA provides day-to-day support for procurement and maximum utilization of equipment, and the NBS Center for Computer Sciences and Technology of the Department of Commerce provides scientific and technical support and consultative assistance to all Federal agencies as well as specific work on the development of measurement criteria and ADP standards.

The role of the Bureau of the Budget is one of overall leadership and coordination of ADP activities in the Executive Branch. This general guidance role includes the fostering of Government support for the development and promulgation of voluntary commercial ADP standards as well as the approval and promulgation of Federal ADP standards.

The General Services Administra-

continued

tion provides Federal schedules of supply for use by agencies in procuring ADP equipment and promotes the maximum utilization of such equipment through cooperative arrangements for joint use of computers and re-use of excess equipment. In support of the standardization program, it will promote the procurement of equipment that conforms to ADP standards adopted by the Federal Government.

The responsibilities of the Center for Computer Sciences and Technology, in providing technical support for the three-agency effort, were defined in PL 89–306 as follows (Sec. III (f)):

> (1) to provide agencies, and the Administrator of General Services in the exercise of the authority delegated in this section, with scientific and technical advisory services relating to automatic data processing and related systems, and (2) to make appropriate recommendations to the President relating to the establishment of uniform Federal automatic data processing standards. The Secretary of Commerce is authorized to undertake the necessary research in the sciences and technologies of automatic data processing, computer, and related systems, as may be required under provisions of this subsection.

The Center is now realining its staff of 200 into six or more action areas of responsibility. These are expected to include offices and divisions devoted to information processing standards, technical information exchange, computer services, management applications planning, systems research and development, and information processing technology.

To understand an organization, one needs to know more than its mission. One needs a feel for its history, its people, the things its people do, and where it is going. The articles that follow should provide a basis for this feel and contribute to an understanding of the Center.

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[1] **Report to the President on the Management of Automatic Data Processing in the Federal Government**, Senate Document 15 (March 4, 1965).

CENTER ADVISES FEDERAL AGENCIES

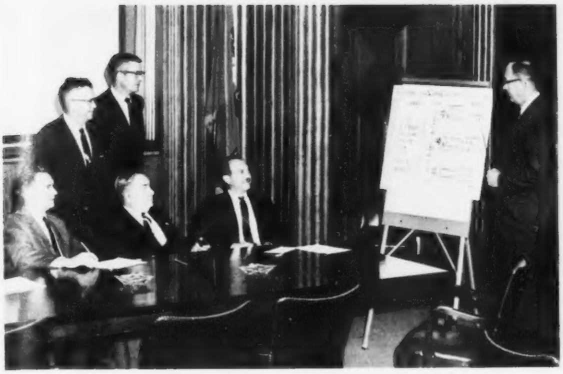
■ More than one hundred Federal activities have received advice and consultation on methods for developing and improving computer-based information systems from the Center for Computer Sciences and Technology since it was established in 1965. The services rendered have covered a broad range, including assistance in computer selection, basic information on system design, reviews of effectiveness of existing systems, recommendations for improved operation, and development of special data processing techniques.

The expanding role of the Center as a consulting service for Government agencies stems directly from the increasing recognition of the degree of expertise that is needed in the development of computer-based management systems. The design of modern information systems requires extensive knowledge of the functions of each agency involved, the use for which equipment is intended, and the performance characteristics of available machines. The research activities carried on by the Center have enabled it to develop a broad background of knowledge and experience that can be of considerable value to other agencies in this field.

The Bureau of the Budget has stated:[1] "No single technological advance in recent years has contributed more to effectiveness and efficiency in Government operations than the development of electronic data processing equipment." Impressive as the achievements attained by the Government through ADP applications have been, there are significantly greater potential savings yet to be realized. The expanded consultative and advisory services provided by the Center represent an effort to help the Federal agencies to achieve this goal through improved cost effectiveness in the conduct of their data processing programs.

Because of the extensive utilization of computer-based systems and the growing number of ADP applications in the Government, the Center is not able to supply assistance in response to all requests from Federal agencies. It therefore concentrates on attacking problems that will have the greatest benefit for the Government as a whole. Its policy is to select specific problems with general implications that can be used as a "pattern."

At the request of the Office of Statistical Standards of the Bureau of the Budget, the Center undertook the evaluation of a proposal (to the Bureau of the Budget) for the creation of a large-scale computer-based national statistical data center to meet the new policy and research needs of Government, industry, and the academic community. The Center made a detailed study of the issues



Members of the Center staff meet with Treasury officials to discuss a computer assistance project. Wendell August, NBS computer systems analyst, is using the easel to explain the information flow in and out of a data bank for recording all foreign loans made or guaranteed by the U.S. Government. Seated at the table are (left to right) C. R. Harley and Henry Bitterman, Director and Associate Director (respectively) of the Office of International Financial Policy Coordination and Operations, Department of the Treasury; and Ralph Hirschtritt, Deputy Assistant Secretary of the Treasury for International Financial and Economic Affairs. Standing behind the table are W. H. Gammon (left), NBS Center for Computer Sciences and Technology; and Volney Taylor, ADP management specialist in the Office of the Secretary of the Treasury.

that would govern the design of an effective Federal Statistical Data Center, which resulted in a special report subsequently published by the Executive Office of the President. The report has since been reprinted in the statistical literature [2] and in Congressional documents dealing with the long-term consequences of the new computer technology.

An example of a study that should serve as a pattern for other agencies is a major management and organization review of the ADP activities undertaken by the Department of Health, Education, and Welfare (HEW). NBS was asked to make a study of the Department to devise a plan for developing information systems and for providing the data processing services required by each agency within HEW. A team of four, three from NBS and one from the General Services Administration, worked 8 months in the development of organizational proposals for providing data processing services to all HEW bureaus.

Requests for assistance from agencies vary greatly. They may differ in the nature of the problem to be studied or in the amount of effort required to reach a solution. Many questions are posed by telephone. One or more telephone calls may be all that is necessary if the Center already has an answer to the problem and can give a quick suggested solution, or if the Center knows where a quick answer may be found and refers the agency to that source. At the other extreme is an in-depth study requiring many man-months of effort, such as the study done for HEW. Even here, the costs and time limitations may vary within wide limits.

Lengthy projects, such as the study for HEW, are rendered to Government agencies on a cost-reimbursable basis. Brief consultative or diagnostic projects, on the other hand, may be provided on a non-reimbursable basis.

For projects requiring a Government-wide approach, it is sometimes possible to use an alternative means for financing. In 1954 Congress established a Management Improvement Fund to assist the President, through the Bureau of the Budget, in improving the management of executive agencies and in obtaining greater economy and efficiency through the establishment of more efficient business methods in Government operations. Use of the Management Improvement Fund has been authorized for an ADP study requested by the Interstate Commerce Commission. The ICC required assistance in determining the feasibility of applying ADP techniques to its activities and operations. A preliminary investigation of the Agency's major objectives and the functions of its operating units identified substantial potential gains in effectiveness and cost savings that would be possible through the establishment of a computer-based system. Both short-range and long-range project proposals for further work based on these findings were made and then funded under the President's Management Improvement Fund.

In performing studies for other agencies, the Center works closely with the agency staff to help develop the in-house expertise of key agency people. The initial phases of a study provide introductory analysis sessions to define the problem. A project proposal based on the result of the brief initial survey is then submitted to the requesting agency. This includes the scope of the assignment, estimated staffing requirements for both the agency personnel and the Center personnel, a proposed work schedule, and the estimated cost. No work is begun until agreement with the agency is reached on a work proposal.

Some typical kinds of assistance offered to agencies by the Center are listed below:

- —help in formulating long- and short-range information processing plans
- —providing objective evaluation of agency ADP plans
- —study of the organization and procedures for management and use of ADP
- —providing counsel in planning and implementing complex data processing projects
- —study of information flow requirements for management information
- —preparing systems specifications for *requests for proposals* for studies

continued

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—monitoring contractor performance
—reviewing performance of computer installations
—planning and conducting feasibility studies
—planning and arranging for executive orientation and staff training.

Two recent instances in which agencies consulted with the Center demonstrate the broad range in the type of services required within any one of the above categories. Both agencies, the Civil Service Commission and the Bonneville Power Administration, Department of the Interior, were concerned with the selection of a computer and both studies involved the preparation of *requests for proposals*, but the types of assistance required by each agency differed markedly.

The Civil Service Commission requested assistance for a Civil Service task force which was concerned with automating the maintenance of the Commission's Government-wide roll of Civil Service retirees. Full-time, on-site assistance over a period of six months was provided to write functional specifications, to issue a *request for proposals*, and to develop selection criteria and establish evaluation methodology for the Commission to use in selecting a replacement computer.

The Bonneville Power Administration requested assistance simultaneously from the Center and from GSA in the preparation of a *request for proposals* for a large-scale computer. The Center was asked to assist by reviewing the draft *request for proposals* and also by reviewing the overall computer selection procedure and computer applications.

Present indications are that the demand for the Center's advisory and consulting services will continue to increase. Thus the Center may be expected to be busy for some time in solving problems such as those mentioned above, as well as new problems that develop in the management and use of third-generation computers. The results of such work can be very useful in providing general methods of approach for solving data processing problems. As experience identifies those areas where agencies commonly require assistance, the Center will develop guidelines for use by agencies in conducting systems studies and in making evaluations in connection with such studies. These guidelines will be made available to all Federal agencies.

[1] **Report to the President on the Management of Automatic Data Processing in the Federal Government**, Senate Document 15 (March 4, 1965).
[2] **The design of a Federal statistical data center**, by E. Glaser, D. Rosenblatt, and M. K. Wood, The American Statistician **21**, 12–20 (Feb. 1967).

GROSCH HEADS COMPUTER CENTER

Herbert R. J. Grosch, nationally known computer pioneer, has been named Director of the NBS Center for Computer Sciences and Technology. Dr. Grosch has a record of long and varied experience which will be a valuable asset in dealing with the many different problems facing the Government in the computer field.

Awarded his Ph. D. by the University of Michigan in 1942, he has directed both industry and university projects. Prior to joining the Center, he was manager at the G.E. Center for Advanced Studies for project DEACON—an on-line, natural-language, data-base system. From 1959 through 1965 Dr. Grosch was a consultant to a number of major computer and information handling concerns. His earlier experience included logical design research at M.I.T. and pioneer computing work in 1945 with IBM at the Watson Scientific Computing Laboratory located at Columbia University.

He is the author of numerous articles on celestial mechanics, lens design and numerical analysis, and in the management field has published items on the installation and operation of large computer facilities.

CENTER PROVIDES COMPUTER SERVICES

■ During the first half of fiscal year 1967, the Center for Computer Sciences and Technology provided data-processing services to 79 organizations including 10 executive departments of the Federal Government, 25 Federal agencies and establishments, the Congress, various state and local governments, quasi-governmental organizations, and universities. These services included problem formulation, programming, computer time, and related activities.

The work associated with the use of the Center's computers is carried out by the Computer Services Division in four operating sections: Business Applications, Scientific Applications, Computer Operations, and Systems Programming and Training.

The Business Applications Section provides analytical and programming support as required for the development of business, management, administrative, and related systems. COBOL is the primary programming language used for these applications.

The Scientific Applications Section gives assistance in the solution of mathematical problems originating in the physical sciences and related data-processing problems. Here the primary language used is FORTRAN.

The Systems Programming staff provides the necessary support to develop and maintain the computer operating systems and general-purpose programs required for the equipment operated by the Division. It also conducts training programs in the use of software and equipment. Finally, the Computer Operations Section has the responsibility for the operation of all the Division's computer and ancillary equipment.

Dorothy Burns operates the console of the UNIVAC-1108 computer recently installed at the Bureau, while William Macko observes the printout being produced. A row of magnetic tape transports used for data input stand in the background.

A new multi-access computer facility was recently installed at the Bureau's site in Gaithersburg, Maryland. The installation consists of a UNIVAC-1108 computer with a main memory of 65,536 36-bit words, auxiliary drum storage of over 273 million characters, eight magnetic tape units, two printers, two card readers, and one card punch. An incremental X-Y plotter is also included in the central facility.

The UNIVAC-1108 is presently operated in a batch processing mode. A priority arrangement is available under which users can obtain either special service at a premium cost or deferred turnaround service at a reduced cost. Within each of the priorities, work is processed on a first-in first-out basis. One high-volume and two medium-volume terminals presently provide remote access to the computer from three other Government agency sites while additional terminals connecting the 1108 with NBS laboratories and other Government agencies are planned in the near future.

Software support for the new computer includes FORTRAN, COBOL, SIMSCRIPT, and the EXEC operating system. In addition, the Center plans to make full use of OMNITAB, a computer language developed at the Bureau for statistical and numerical analysis.[1] OMNITAB enables the nonprogramming scientist to make use of a computer in his computations as readily as he would a desk calculator. It also provides a readily accessible common file of currently accepted values of physical and chemical constants.

At some future time the Center also plans to provide software support for time-sharing operations, as required for conversational and text editing applications.

Computational Assistance

Examples of assistance which the Computer Services Division is now giving to other Bureau laboratories and to other Federal agencies include the following:

Department of State

This project involves a series of programs, tabulations, and special analyses of the position data and career data of the personnel of the Department of State. The project has two major objectives. The first is to provide a basis for manpower planning in terms of how many officers and what skills are needed. The second objective is to provide data, using information from the manpower studies, to the career management programs for guidance in developing the needed skills and experiences in the officer level personnel.

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DEVELOPMENT OF FEDERAL ADP STANDARDS

■ Within the Center for Computer Sciences and Technology, the Office for Information Processing Standards has the primary responsibility for matters concerning ADP standards. The Office works to improve compatibility in Federal ADP equipment by developing uniform Federal standards for automatic data processing equipment, techniques, and computer languages. It also works closely with the USA Standards Institute (USASI) to support the development of voluntary ADP standards, and it provides advisory and consulting services to government and industry on ADP standards.

Once the Office for Information Processing Standards has determined the need for a Federal ADP standard, it proceeds to develop a recommended standard which NBS sends through the Secretary of Commerce to the Bureau of the Budget for approval and promulgation. Whenever feasible, voluntary standards will be used as the basis for recommending Federal ADP standards. This will not always be possible, however. Time may not be available to develop a voluntary standard, or the area of standardization may not be of interest to private organizations. For such cases which require a specific Federal standard, the Office for Information Processing Standards has adopted a formal procedure for developing recommendations for Federal ADP standards. This procedure is in three phases, as follows:

FIRST PHASE—Project Nomination

(1) *Initiation*

The subject of the Federal ADP Standard is identified and tentatively named. Standardization projects may result from requirements submitted by Federal Departments or agencies, or from action of domestic and international standards bodies.

(2) *Validation*

The extent of need for the standardization subject is determined and the scope of the project is defined. This step may require research to clarify or identify requirements.

(3) *Information Collection*

Appropriate data files are set up to collect related information, including bibliographies and the technical literature, from USASI, the International Standards Organization, industry, government, and technical sources.

Major current projects now in the First Phase are:

Glossary of ADP Terms
Data Interchange Codes
Magnetic Tape Measurement Techniques
Time Sharing and Remote Console Considerations
RFP, RFQ, and Contract Formats
Hardware Interfaces.

SECOND PHASE—Standard Development

(4) *Working Draft*

A working draft of the proposed standard is prepared. This may involve modifying and augmenting an approved voluntary or industry standard, or preparing an original draft if no suitable proposals are available.

USA Standards Institute Task Force X3.3.5, Systems Performance, meets at the Boulder (Colo.) Laboratories of the U.S. Department of Commerce in June 1967. The Center for Computer Sciences and Technology works closely with such USASI groups in the development of voluntary ADP standards, which can often serve as a basis for Federal ADP standards. Left to right: L. M. Borden, IBM Corp.; R. E. Huettner, Honeywell; S. K. Freeman, Consolidated Electrodynamics Corp.; R. Kerker (standing), General Electric Co.; R. T. Moore, NBS Center for Computer Sciences and Technology; W. B. Dickinson, Goddard Space Flight Center, NASA; R. J. Linhardt, RCA Laboratories; and G. J. McAllister, Bell Telephone Laboratories.

(5) *Consultation*

If appropriate, a small working group is formed to perform specific and clearly defined tasks relative to preparing a standards proposal. Such a group will be useful in presenting expert diverse viewpoints, selecting alternatives, resolving well-defined controversy, or defining a need for additional information.

(6) *Coordination*

The proposed draft standard is revised and coordinated. The levels and degree of coordination required will depend upon the past history of the proposal. All approved USA Standards, for example, will require minimum review as compared to an original draft, which may require substantial work to develop a strong justification. When appropriate, views and comments will be solicited from manufacturers, suppliers, and Federal Government users. Draft recommendations will be discussed with the staff of the Bureau of the Budget, with the Council on ADP, and the Inter Agency Committee on ADP.

(7) *Views and Comments*

Information resulting from responses noted above is used to prepare a Draft Recommendation for a Federal ADP Standard. The Draft Recommendation is forwarded for formal review and comment to Federal Departments and agencies, along with appropriate historical and background information.

(8) *Consensus*

Comments and views from Departments and agencies are reviewed to determine the existence of a consensus. Discussions may be required to resolve objections or problem situations. In the event that a consensus does not exist, the project is returned to step 4 or 5 above, as appropriate.

Projects in the Second Phase are:

FORTRAN Standard Reference
COBOL Programming Language
Optical Character Recognition Character Set.

THIRD PHASE—Recommendations

(9) *Recommendation*

The final Draft Recommendation is prepared together with historical, background, and justification materials.

(10) *Forwarding*

The completed Draft Recommendation is forwarded by the National Bureau of Standards to the Secretary of the Commerce for signature and subsequent forwarding to the Bureau of the Budget.

To date, the following Draft Recommendations have been forwarded to the Bureau of the Budget:

Standard Character Code for Information Interchange
Standard Perforated Tape Code for Information Interchange.

CENTER PROVIDES *continued*

NBS Administrative Operations

A system of COBOL programs is being developed to support automation of various administrative operations of the Bureau. These include payroll, personnel, accounting, budget, and supply. The entire project will, in its final version, provide a fully-integrated resource management system.

NBS Scientific Programming Support

Programming and consultative services are provided in support of NBS technical activities. This effort is largely in assisting NBS scientists with problem formulation and in writing FORTRAN programs.

Department of Commerce Personnel Data Bank and Reports System

A basic personnel system for the agencies within the Department of Commerce is being programmed to specifications recently developed by a Departmental task force. The programs are being written in the Commerce COBOL subset, which permits installation of the system on any of the computers currently operated within the Department. It is expected that each Commerce bureau will, upon installation of the basic system, expand the capabilities of the system to meet its own unique requirements.

Economic Development Administration

Full-time programming assistance is being provided to the Economic Development Administration in support of a computerized information system which will include a data base, a program library, and the computer software required to facilitate their use. The basic programming language being used in this project is SIMSCRIPT, a general-purpose simulation language which is especially well suited to the type of file management and information retrieval system being developed by EDA.

[1] **OMNITAB: A second-generation general purpose computer program**, NBS Tech. News Bull. **47**, 14–15 (Jan. 1963), and **Improved OMNITAB gains wide acceptance**, NBS Tech. News Bull. **49**, 179–191 (Nov. 1965), as well as NBS Handbook 101, **OMNITAB—A Computer Program for Statistical and Numerical Analysis**, by Joseph Hilsenrath, Guy Ziegler, Carla Messina, Philip Walsh, and Robert Herbold, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $3.

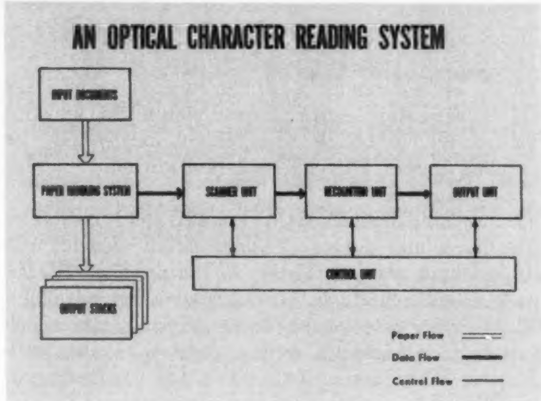
STANDARDS FOR OPTICAL CHARACTER RECOGNITION

A Review of the NBS Program

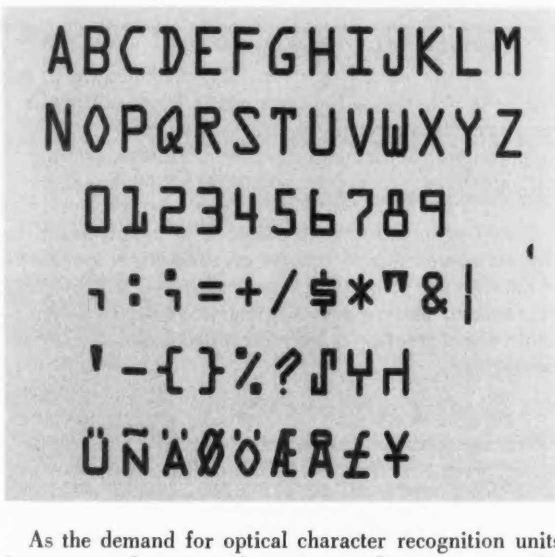
■ With the tremendous growth in the use of automatic data processing throughout the world, the need has arisen for some rapid, accurate means of translating material prepared on ordinary office machines into computer language. The transcription of such material to punched cards or punched paper tape is slow, costly, and offers a chance for errors to creep into the data being fed the computer system. Within the last decade the development of optical character recognition (OCR) systems has provided a means of skipping this additional step, or at least an improved method of performing the transcription. Such systems scan a printed text, "read" the individual characters, and feed them into the computer system. OCR systems are especially useful when the supply of keypunchers lags far behind the demand for them, and present indications are that this lag will increase rapidly in the future.

Today there are a number of different kinds of optical character readers on the market, produced by at least six different companies. Closely related, but less sophisticated, are the optical mark read systems and bar code readers which are being manufactured by about a dozen companies.

The early readers were slow in operation, limited to a special font, and characterized by relatively high reject and error rates; they required rigid specifications for acceptable input documents. But the situation is quite different now. Present-day readers are operating at scanning rates of 2400 characters per second, and can handle documents at rates up to 1000 per minute. Reject rates of less than 1 character per 10,000 and substitution error rates of less than 1 per 100,000 characters are common. Operating under stored computer program control, page readers can now modify their reading pattern to coincide with the format of the input document and according to the content of the data being read. Several readers are reading lower case characters and others may read many font styles, including up to 300 shapes. A few are successfully reading constrained hand-printed alphameric characters. With the OCR field in this state of development, the next five years are expected to produce a substantial increase in the number of OCR equipments in the Federal Government.



Above: In an optical character reading system, the paper handling system brings material to be read to the scanner and then moves it to the output stacks. The scanner sends electrical signals corresponding to print on the input document to the recognition unit which determines what characters in its vocabulary are being read. Signals from the recognition unit go to the output unit where they are used to punch data in cards or paper tape, to write on magnetic tape, to control external equipment such as letter openers, or to enter the data into an on-line computer for processing. Below: USA Standard Character Set for Optical Character Recognition (USASCSOCR). The Center is now working on a Federal ADP Standards Recommendation that will establish this character set as a minimum standard for certain prescribed Federal OCR applications.



As the demand for optical character recognition units increases and more and more manufacturers enter the market, the need for standards in the field becomes increasingly evident. It becomes necessary, for example, to put certain definite requirements on all OCR readers in order that competitive bidding may take place on a common basis. Then a user can know at least the mini-

minimum capabilities of the equipment he is considering purchasing. Standards are also needed so that as data systems interact with one another, the same input document may be readable by equipment of more than one manufacturer. This requires common fonts and handling procedures. Finally, equipment should be sufficiently standardized that equipment made by one manufacturer can be used as backup for equipment made by another. Any breakdown in a system handling large quantities of data can be extremely costly if backup equipment is not immediately available to take over.

To meet the needs for OCR standards, consideration must be given to several areas: The minimum requirements of the reader; the specifications of paper, ink, print quality, and forms design for the input document; the character set or sets to be read; and the common operating procedures to be followed. Much work toward the development of such standards is being done by voluntary standards groups, both in this country and abroad. Within the Federal Government the potential use of many such systems requires the establishment of Federal standards wherever possible. These standards should, insofar as possible, agree with industry's voluntary standards where such standards exist.

The program of the Center for Computer Sciences and Technology in regard to OCR standards consists of the following activities: (1) Actively working with voluntary standards groups, in which the Center takes the position of a consumer; (2) determining the needs for Federal OCR standards; (3) obtaining the technical information necessary to formulate useful standards; (4) obtaining the cooperation of user agencies of the Government in the development and application of these standards; (5) drafting standards to be forwarded to the Bureau of the Budget for promulgation; (6) maintenance of Federal ADP standards; (7) providing assistance to OCR system users.

The OCR field involves several industries and the Center has endeavored to work with and to encourage the voluntary standards groups in these industries. For example, Center staff members have membership on the OCR committee of the Technical Association of the Pulp and Paper Industry in order to help in formulating specifications for paper for OCR use. Likewise, the Center is represented on American Society for Testing and Materials F8 subcommittees concerned with measurements for carbon paper and inking ribbons, and on several committees of the United States of America Standards Institute (USASI), concerned with problems related to OCR, such as print quality and character sets for OCR, keyboards for typewriters for OCR, and transmission codes for special OCR symbols.

To determine the needs for Federal standards in this field, members of the Center staff have visited agencies that have OCR systems or plan to install them, in order to discuss their problems, especially those which might be solved through standardization. They also have visited commercial firms to obtain similar information.

To avoid unrealistic requirements, Center staff members have visited manufacturers of OCR equipment, forms-converting companies, and manufacturers of carbon paper and ribbons, and have consulted with paper and typewriter manufacturers. Specifications for standards are suggested on the basis of the data provided from these varied sources.

The NBS program includes consultations with users in regard to standards, so that requirements may be established which most Government users of OCR will be willing to follow for the sake of the benefits to be derived. A technical representatives group has been formed among the Federal agencies to help arrange and take part in such consultations. Seminars are held so that Federal users may become better informed about the field of OCR, and also to provide opportunity for them to comment on proposed specifications for OCR standards. Where NBS work on OCR standards impinges on that of other groups such as National Archives and Records Services, meetings are arranged to obtain mutual understanding and help.

All these activities provide a broad background for writing technical specifications for OCR standards that can be beneficial to Government users, the reader manufacturers, forms producers, and others involved in the field. At present the Center is working on the following:

(1) Adoption of the USA Standard Character Set for Optical Character Recognition (USASCSOCR) as a minimum set for Federal OCR applications.

(2) Design of forms to be used as input to Federal OCR applications. The specifications for forms layout and paper are now in draft form. Work is continuing on the specification of standards for inking technology and print quality.

(3) Adoption of a set of standard keyboards for OCR applications. At present, this work is being carried on through the voluntary standards activities of USASI, in the hope that voluntary standards will be agreed upon the which can then evolve into Federal standards.

Other areas which have scarcely been touched upon but which appear able to benefit by standardization, are use of standard symbols for control purposes, standard methods of handling OCR center operations, and standard methods for quality control of input documents. Some work is in progress at NBS on the development of instruments for this last item.

Once Federal standards have been promulgated for the OCR field, requirements will arise for modifications of the standards and for interpretation of their specifications. NBS will maintain a file of the standards documents so that these will always be up to date. The needs for modification will be investigated and if such action is warranted, the Center will help introduce such modifications into voluntary and Federal ADP standards. For example, there already is need to add to the USASCSOCR certain symbols

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ACHIEVING COMPATIBILITY IN INFORMATION EXCHANGE

■ As computer systems do not ordinarily communicate in graphic symbols nor operate upon them, the machines must make use of codes—bit patterns of "ones" and "zeros"—which form the "machine language" representation of the individual symbols or characters in a set. For meaningful interchange of information between computers, either they must use the same code or else one code must be translated into the other. Additional problems arise unless the same set of characters is used by the sender and receiver.

To facilitate interchange of information among communication systems, data-processing systems, and associated equipment, a major standardization effort has been underway for the past six years, both nationally and internationally, to provide a universal language of machine intercommunication. This effort has now culminated in the development of an internationally acceptable standard coded character set which has received a favorable vote by the International Organization for Standardization (ISO) as the draft ISO Recommendation 6- and 7-Bit Coded Character Sets for Information Processing Interchange. As this article is written, approval of the draft Recommendation by the ISO Council is expected in June 1967.

ISO Recommendations are implemented by means of national standards within the various countries. In the United States the implementing standard for the ISO 7-bit code is the USA Standard Code for Information Interchange (USASCII), now awaiting approval in its second revision.

A closely related standardization effort is directed toward the development of a new "telegraph alphabet" or code for international telecommunications. This work began, somewhat later than the ISO work, in the International Telegraph and Telephone Consultative Committee (CCITT) with the formation of a Working Party. The Working Party studied the work done in ISO on the 7-bit code and eventually recommended that a new CCITT telegraph alphabet be based on the ISO code for the use of those not satisfied with the more limited possibilities of CCITT Alphabet No. 2 (a 5-bit code). A joint meeting of ISO Subcommittee 2 (Codes) and the CCITT Working Party was held in April 1966 in Paris to resolve minor differences between the 7-bit codes proposed by the ISO and the CCITT. Changes were agreed to by both bodies and are included in the ISO Recommendation.

Appropriate changes to the USASCII, for conformance with the ISO and CCITT 7-bit codes, have been voted on favorably by USASI Sectional Committee X3. This proposed revision is now before the USASI Information Processing Systems Standards Board (IPSSB) for approval.

Development of USASCII

The steps in the development of USASCII may be of interest as they shed light on the intended use of the code. During its development USASCII has been influenced by, and has in turn influenced, the work on codes underway in the European Computer Manufacturers' Association (ECMA), in the ISO, and in the CCITT.

In this country, the work began in 1960 with the establishment of American Standards Association (now USA Standards Institute) Subcommittee X3.2 under Sectional Committee X3. Early membership consisted of representatives of the ADP industry, the communications industry, and the Federal Government. The objective was the establishment of a single standard coded character set that would satisfy the requirements of both information processing and communications. From the standpoint of keyboard design, the code should permit low-cost construction, but should depart as little as possible from keyboard arrangements familiar to most typists. The single most important requirement was that there should be an orderly relationship between the code representation of characters and their normal sequence in the human environment. Thus the code sequence for the characters A to Z should be the same as the letter sequence; this should also be true for the numbers 0 to 9. The "space" character and other "separator" characters, such as the period, hyphen, and slash, should be lower in the code sequence than the numbers, letters, or other symbols that they are to separate or delimit. In other words, the structure of the code should have a "natural" collating order insofar as practical. These were but a few of the many factors that had to be resolved to reach national and international agreement.

All known codes were examined but none were found to be satisfactory. Shortly before the work began in Subcommittee X3.2, the Department of Defense had adopted the 7–bit "Fieldata" code as a DOD standard for communication systems. This code was satisfactory to the communications industry, but it did not satisfy the ADP industry as it did not have the desired relationship of codes and characters for information collating purposes.

The Subcommittee therefore decided to undertake the development of a suitable code. The result was the American Standard Code for Information Interchange, or ASCII as it was commonly called. This code, the first version of ASCII, was approved in June of 1963 and assigned the number X3.4–1963. A large section of the code table was left blank, the characters to be filled in after further investigation.

Additional national and international code development work resulted in a revision of the ASCII which was approved in December 1965. A lowercase alphabet was added

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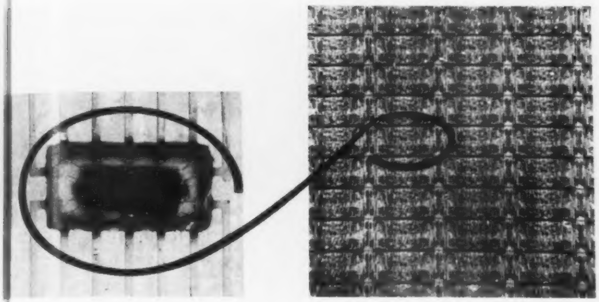
COMPUTER TECHNOLOGY: A FORWARD LOOK*



Industry can now mass-produce complex electronic circuits by depositing and etching conducting, semiconducting, and insulating materials in patterns forming "integrated circuits." The circuit elements for many units are produced on a large substrate, as shown on the left. The individual units are then cut apart, tested, and the good ones mounted on headers (right) to facilitate making connections.

■ All signs indicate that the development and installation of computer equipment will proceed at an accelerated pace during the next decade. Even without spectacular breakthroughs in computer technology in the late 60's or early 70's, the momentum which the computer industry has gained will very likely be maintained. The evolution of later-generation devices and system techniques will lead to more complex and efficient systems in an increasing number of applications. This continued growth may be hampered by temporary slack periods in the rapidly expanding economy. More serious, perhaps, will be the lack of a sufficient number of trained computer professionals to design and develop the systems required for many of the newer application areas. Even so, the prospects for rapid growth remain quite favorable. Given this prediction of continued prosperity in the computer field, it is appropriate to examine those developments in computer technology that will have a significant effect over the next several years.

New devices and fabrication techniques

As has been true in the past, the availability of logic and storage components from which computer systems can be constructed will have an important effect on the way in which these systems are designed and used. The field has reached a point at which logic speeds are measured in tens of nanoseconds (a nanosecond is one billionth of a second), while memory speeds for the fastest large-volume storage are measured in hundreds of nanoseconds. This storage, usually magnetic core or thin film, is fairly expensive in large quantities. Bulk cores with cycle times of several microseconds, as well as various rotating disks and drums and other mechanical devices having average access times of tens of milliseconds, are necessary to provide an economical system with sufficient storage capacity.

The use of fast logic, in which the speed of transmission of electronic signals (about 30 cm per nanosecond) is a limiting factor, is becoming economically feasible as newer batch fabrication techniques are developed. Discrete components have given way to integrated circuits placed on conventional etched circuit boards. This fabrication technique is in turn giving way to large scale integration (LSI), in which sheets of logic elements are produced as a unit. Already, some very large computer systems are being designed using such techniques, and within a few years systems of all sizes should incorporate the technology.

The development of higher-speed conventional memory devices, of cores and thin films, has slowed, and progress with such devices in breaking the hundred nanosecond barrier will probably take some time. In view of the economy that should accompany widespread use of LSI, it may become less expensive to use LSI logic elements as main memory elements, at least for some portion of primary storage. Even today some systems have scratchpad memories constructed of machine logic elements, so that the fast processor logic is not held back by the slower memory capability. This incompatibility between logic and memory speeds has led to increased parallel operation in processors and more complex instructions as an attempt to increase overall system capability. It has also led to the introduction of microprogramming, in which instruction execution is controlled by a read-only memory. The fast access time of this memory allows full use of the speed capabilities offered by the fast logic.

The availability of economical LSI circuitry will make possible the addition of greater amounts of logic to computer systems, not only to increase the capability of individual processors, but to permit inclusion of more of them in a given system. This will lead to greater emphasis on multiprocessor systems, a design configuration that is now becoming popular for highly reliable, high-capacity systems. It will also allow the inclusion of special features which will remove some of the burden from the complex software required for such systems. These features will enable executive systems, or monitors, to function more efficiently. Such developments, improving system operation at the hardware and executive software level, will permit more economical systems to be designed, yet at the same

*Substance of a talk presented by T. N. Pyke, Jr., of the NBS Center for Computer Sciences and Technology at an NBS staff meeting on June 28, 1967

continued

time will allow compatibility at the users' level with earlier systems. It will thus be possible to introduce and adopt programming-language and other user standards without impeding progress in the development of newer, more economical systems.

New machine organizations using the latest technology, including array-type systems with large numbers of processors, will be designed and implemented. These systems may prove very useful for problems having many parallel components as well as for conventional programs, with the system controlled by an appropriate software monitor.

The compactness of LSI logic will change the appearance of computer systems. The logic packages of the largest systems will be completely dwarfed by the storage and peripheral equipment. The central processor of smaller computers may be cigar box size or smaller. Table top computers, constructed of integrated circuits and having substantial computing capability, are now on the market. With the advent of more powerful computers of this type, accompanied by more convenient input-output devices, the small computer will enjoy widespread use.

For many applications it will be possible to have sufficient computing power available locally without the need for a large remote computer system. For those applications requiring the computing power, storage capability, and interaction with other users that can be obtained from a large system, inexpensive remote terminals containing substantial logic will be available.

A large effort is now being expended on the development of mass storage devices. Larger and faster bulk cores are being designed. Drums operating with parallel transfer and with logic for queuing access requests, thus optimizing drum operation, are forthcoming. Disk units with an individual head per track are becoming available and devices such as data cells promise many billions of bits of storage at a reasonable cost.

Donald Shook operates a remote console that gives access to a computer, via a telephone line. Many such units can be used with the same central computer. Within the next decade remote computer terminals are expected to attain widespread use in a great variety of applications.

The very important problem of providing efficient access to this mass storage remains to be solved. Various schemes for organizing mass memory elements have been proposed, with storage arranged into levels by size and speed and with hardware for automatic transfer among levels as required. Efforts have begun to make the entire memory appear as one logical unit to the system user rather than as a primary and secondary memory with separate addressing mechanisms. In large time-sharing systems the means for organizing memory is of prime importance, and the next several years should bring a variety of solutions to this problem. The similarity of this problem in various systems and the need for access to data stored in several such systems make this a fertile area for the consideration of standards, at least in the external addressing of such mass memory, within a few years.

The enthusiasm with which on-line operation of time-shared computer systems has been accepted has resulted in considerable work on man-machine terminals for access to these systems. Keyboard terminals alone have been supplemented by cathode ray tube (CRT) assemblies similar to television consoles for display of groups of characters and line drawings. Present goals call for the development of inexpensive, yet effective, terminals for mass use, as well as more expensive terminals for the optimization of the man-machine interface. The cost of the terminal, the cost and bandwidth requirements of the communication line, and the burden on the computer system are all objects of reduction efforts.

The 1970's will see thousands of on-line terminals throughout this country and the rest of the world. In fact, the pushbutton telephone has been hailed by many as a computer terminal, widely available, waiting for ingenious entrepreneurs to capitalize on its capabilities. A wide variety of special terminals, such as those for ticket issuing and collecting, and for special-purpose clerical operations, will flood the country, as many organizations, in both the public and private sectors, take advantage of the new technology. Some of these terminals will incorporate very advanced methods for man-machine interaction, including the use of audio input and output.

These new devices will have higher reliability than their predecessors. Stricter controls over fabrication, as well as the newer technology itself, will lead to more reliable components. Greater modularity of the systems will mean easier, quicker diagnosis and replacement of faulty parts. Availability of more logic and other equipment for larger systems will allow greater redundancy, parallel paths and other multiple capabilities as desired, for extremely high total system reliability.

New computer systems

The predominant batch-processing systems of today

will be joined and in many cases replaced by on-line systems during the coming decade. Direct access to smaller computers by individual users and simultaneous access by many users to larger time-sharing systems will bring computing capability to a wide range of users. For those installations requiring highly efficient solution of data-processing problems or complex scientific problems, the batch-processing facility not greatly different from most of today's systems will prevail. The software operating system for such installations, however, will be more effective than today. Most systems will be of adequate size to support a multiprogramming operating system, in which the input-output of one program overlaps with the processing of another. In such systems the most efficient use of all resources is very important.

In a large number of installations the requirement for brute force operating efficiency will give way to other requirements: A need for remote data collection and entry into the system, for interactive man-machine communication for the solution of a multitude of problems, and for the use of the system as a communications device for conveying newly developed programs and ideas to all its users. The need for these capabilities, accompanied by the technological advances in machine logic, memory organization, and remote terminals that have been discussed above, will lead to the installation and operation of many time-shared computer systems. With such systems a large number of users, each at a remote terminal, can have simultaneous access to a computer facility. This system organization has been referred to as a computer utility, in which the users draw on a central system for computer power, just as electrical power is drawn by turning on a light.

By the use of such systems, and by their interconnection into a computer network, large numbers of users throughout a wide geographical area can have access to a common data base and to a very large number of programs and problem-solving mechanisms. Such a network will allow the decentralization of a data base, yet will give authorized individuals convenient access to any part of it when they need it. A network can provide liaison between institutions or groups working in similar fields, giving each the advantage of the other's computer capabilities and allowing each to share the knowledge gained from the other's work. A network can provide intercommunication among groups in different areas, resulting in cross-fertilization of efforts, with potentially valuable results. Both a single computer utility and a network involve a conjunction of two fields, computer technology and communications technology.

Within 5 to 10 years networks of computer systems will appear throughout industry, universities, and the Government. There will be liaison among the various efforts to develop these systems, and there will be interconnection of the resulting networks. So that this process can occur effectively, there will have to be coordination among these groups, and standards for communication and system operation will need to be discussed and adopted.

A wide range of applications

At the present time most organizations having substantial payroll, inventory, or similar operations have introduced data processing equipment to help with these tasks. Organizations having responsibility for large collections of documents and data are likewise depending on computerized storage and retrieval techniques. Research institutions of all types have found a computer system essential for the satisfactory execution of their work. The computer's assistance is proving quite valuable in the arts and humanities as well as in the sciences.

Computer systems of the future will handle these applications even better than they do now. Both the hardware and the software will conform more closely to the special needs of users, as the external face of the machine will be more problem-oriented.

The advent of the newer types of systems, which will be variations of on-line systems, will bring the computer within range of many new users. Computer-assisted instruction will become an important tool for the teacher to help him deal better with the individual needs of students. Computer-aided design will assist the architect and other creative individuals to easily generate new designs, to immediately observe the effects of new ideas, and to communicate these ideas to the persons and machines that put their designs into practice. Computerized management information systems will place all the data required for decisions at the fingertips of managers and will communicate the resulting decisions throughout the organization quickly and efficiently. Computer-based systems for hospitals will make them better able to provide for the needs of patients. The publishing business will make use of computer technology to decrease the costs and to increase the speed of the entire publication process, including the preparation of text for printing, the actual printing process, and the distribution of the finished product.

On-line terminals in offices and homes will give large segments of the population direct contact with the power of the computer to help them with their specific problems. Widely-known standardized languages for man-machine interaction will be more natural and easier to use than now, so that conversation with computer systems will be straightforward and no longer a chore.

During the next decade the computer will affect, either directly or indirectly, almost every aspect of our daily living. Its application will be so widespread and its impact so great that few will escape its influence. It will allow man more freedom from routine and unpleasant tasks and at the same time will increase the overall effectiveness of every organization with which he is associated. If properly guided, this availability of computer power will help man to fulfill his greatest potential.

FUTURE OF THE CENTER FOR COMPUTER SCIENCES AND TECHNOLOGY*

■ An indication of the rapid growth and maturation of the computer field is the speed with which the names and acronyms of the first electronic computers have been replaced by numbers. Romantics still bewail the demise of such individualized aggregates of electronic circuitry as ENIAC, MANIAC, SEAC, ORACLE, FLAC, and kindred machines. The ubiquitous "AC" appeared in most such names; GEORGE and Pilot are the only exceptions that come readily to mind. The increasing use of social security numbers for individuals and all-digit-dialing in place of the traditional telephone exchanges are continuing evidence of depersonalization, fostered in large part by today's 360's, 1108's, 5500's, and other numbered descendants of the "AC" family.

The Bureau, as discussed in greater detail elsewhere in this issue, has been a major contributor to the development of computer technology. The importance of the NBS role is attested to by the large number of former staff members who have been called to positions of responsibility in the information processing programs of universities, industry, and other Government agencies where they are still making major contributions and training the computer scientists and technologists of the future.

In less than two decades we have seen the advent of four generations of electronic computers, counting from the zeroth generation of individually designed and constructed one-of-a-kind machines to the present mass-produced, solid-state, multiprogrammed machines. In view of the radical changes in computer technology that have taken place over this period, along with the development of a new major industry devoted to computers and their applications, it is important that NBS now give careful consideration to its role in computer sciences and technology. The following recommendations are made in this context.

First of all, it is important that the present standardization program of the NBS Center for Computer Sciences and Technology, which involves recommending Federal ADP standards for promulgation, be extended and broadened in two directions:

(1) A continuing postaudit should be made of the effect of each new Federal ADP standard after it has been promulgated by the Bureau of the Budget. To the extent possible, the postaudit should identify the net financial effect of the standard, the effects of adoption on performance and productivity, and related effects outside the Government. The audit should be as objective as possible and should try to pinpoint savings that are real and can be demonstrated without resort to bookkeeping subterfuges. A uniform language, for example, may reduce duplications of effort, but only at the expense of greater processing time; thus no real saving may result. Such postaudits will provide continued guidance on the direction and value of future standardization efforts and will, at the same time, indicate the desirability of modifying or terminating existing standards.

(2) The term "standard" should be broadened to include guidelines and criteria for the most efficient management of ADP equipment and installations. In this area the Center should address itself to such problems as the following:

(a) Considering the uniqueness of local environmental peculiarities, what guidelines may be derived to measure the economic value of a new application? Are there other overriding administrative justifications?

(b) How can one compare the throughput of work of different types on different machines in differing environments?

(c) What criteria may be established for reasonable size and composition of staff, expenditures for peripheral equipment and supplies, and turnabout time?

(d) How can one measure technical obsolescence, increased maintenance costs, and their impact on available computer time?

The development of management guidelines and criteria should be the responsibility of persons who are actively engaged in rendering advice and counsel to management. Thus the broadened standards activities should go hand in hand with a broadened program of consultative and advisory services to management within the Government. The Center has been designated as the Government-wide source of such consultative advice. Continued exercise of this function on the broad front that is needed will ultimately depend on the confidence other agencies have in the consulting staff of the Center. Personnel policies and problems are discussed below.

Consultative services to other agencies and special assignments undertaken for them will not be restricted to management problems, although they may be problems of management. Thus, while the design and construction of complete computer systems can best be left to industry, the Center must continue to maintain a broad, hands-on understanding of evolving technology and be able to exploit this technology in a wide variety of applied disci-

*Substance of a report by Jack Moshman, of EBS Management Consultants, Inc., presenting his views regarding the future program of the Center. Dr. Moshman has been engaged, under contract with his firm, to advise the Director of the NBS Institute for Applied Technology on the program and activities of the Center.

plies. Such competence requires judicious participation in current research and development projects. The criteria for choice of projects will naturally include

(a) the resources of the Center, in terms of personnel and facilities;

(b) potential value of the project to the Government;

(c) relationship to other Center activities; and

(d) contribution of the project to the professional development of the Center staff.

Examples of projects in which the Center might well participate include problems of data communication, the development of techniques for the processing of nonnumeric information, and studies of the nature of recording media used for storing data.

The Center now operates a large-scale computer service program for Government agencies and some of their contractors (p. 155); it is a logical place for this Government-wide activity. The program should not only provide service on one of the most modern computers and associated programming services for any computer, it should also offer a means by which experimental techniques in computer operations and scheduling and in computer operating systems can be investigated in a realistic, live environment. The fruits of such experimentation will eventually find application throughout Government and in industry as well.

An obvious area of experimentation for the immediate future should be in techniques of time sharing. A joint activity is needed that will exploit analytic techniques, software developments, and empirical operations data.

Problems of file security are now of great concern in many areas. Too often, scare words becloud the issues. A "dossier" stored in a computer produces a greater emotional reaction than does a "file." What is needed is a dispassionate investigation of hardware and software techniques which will truly concern itself with restrictions on unauthorized access to copy, or to change, files. Behavioral scientists should participate to consider the many related human operating and administrative problems. The possible benefits (of which there are many) of large, centralized files should be investigated along with their problems.

The Center should be continuously alert to anticipate areas of broad concern or potential so that it can provide fully-informed technical advice and recommendations. For example, changes in patent and copyright laws may have broad implications. Their possible effect in the computer field should be fully investigated. The possible piggybacking of economic, demographic, intelligence, and other data on existing, but under-utilized, broad communications systems may be a suitable area of investigation. Suggestions for such projects should be positively encouraged.

The fulfillment of the Center's responsibilities requires access to a broad reservoir of information on information processing technology, personnel, and practices. At present there is no single source one can go to for such information. The Center itself would appear to be *the* logical place within this country to assemble and maintain authoritative statistics on ADP equipment, people, and installations. How else can the impact of the Center's activities be estimated? How else can we really evaluate the many conflicting, but uniformly astronomical, claims regarding the number of new computer personnel needed in 1970, 1975, and even 1984?

What can the Center do to help alleviate the existing and expected shortage of trained computer personnel, besides continuing its work on standards and related projects that contribute to greater efficiency and productivity? What can the Center do to better meet its own needs for adequately-trained personnel?

Among consulting and accounting firms it is recognized as a fact of life that they tend to lose many of their best people to their clients. The Center's work is such that it also has this problem and thus requires a continuing infusion of new talent. In scientific and technical fields individuals are strongly attracted to those organizations whose staff includes recognized leaders in their field. To the extent that leaders in the information processing field can be attracted to the Center's permanent staff, substantial benefits should result. One must recognize, however, that these people are scarce. Nevertheless, the permanent senior staff might well be supplemented by outstanding members of the academic and industrial communities. University people could spend sabbatical years and leaves of absence at the Center, pursuing research of mutual interest to themselves and NBS while also contributing to the Center's continuing program. Their presence would not only help the Center's program and advance their own research, but would also be a strong attraction for younger recruits.

Other senior contributors to the program might be obtained by encouraging various Government agencies to detail members of their staff to spend six months or more at the Center working on problems of interest to their agencies. In like manner, the Center should continue to encourage industry to nominate individuals as Research Associates to participate in activities of interest to their firms. Assignment to the Center should carry an aura of prestigious recognition of past attainment and continued promise.

The Center should undertake a consistent long-term program of recruiting graduates of the many computer science programs in universities. The recruiting program should take advantage of the many student chapters of the Association for Computer Machinery and could also benefit from recommendations on the part of professors who may have spent a previous period in residence at the Center.

Inducements to attract recent graduates would include the prestige of working at the Center for Computer Sciences and Technology, the participation in many projects of major importance, and the opportunity to work closely

continued

with professionals of international repute. Another inducement would be the opportunity to continue one's graduate education in the NBS Graduate School. The extension of the present graduate programs, in which local universities provide instruction at the Bureau, should be encouraged. The rapid growth of the scientific community in the region surrounding the Bureau's Gaithersburg, Md., laboratories offers a large potential student body and faculty pool. Providing summer assignments for undergraduates and participating in cooperative work-study programs sow seed for future harvest.

Finally, an intern program could materially assist other agencies in meeting their staffing needs. The intern program should provide formal instruction and on-the-job training to produce individuals who could contribute significantly to the ADP programs of various agencies. To the extent that academic credit could be given the participants, the program would be that much more attractive.

The above recommendations cover the needs of the Center's current program. Back of the Center stands the Bureau's long history of outstanding achievement and innovation in the field of information processing. Given management support, adequate staffing, and a well-planned program of research and development in frontier areas, the Center should continue to render valuable assistance to both government and industry.

TECHNICAL INFORMATION EXCHANGE PROVIDES ADP SUPPORT

■ The Technical Information Exchange (TIE) of the NBS Center for Computer Sciences and Technology has now been in operation for a year as a specialized information center in computer sciences and technology. Ultimately it will offer broad referral services for items in the data processing literature and will have some of this literature on its shelves. The collection will include not only formally published items such as books, reports, and periodicals, but also informal literature such as background material for ADP standards, requests for proposals and responses to them, contracts, and specifications and trade literature furnished by suppliers of ADP equipment and services. The Exchange also collects information on projects, personnel, seminars, courses, lectures, and meetings.

Although the information collected is of broad utility, the Technical Information Exchange's basic function is to provide technical support to the rest of the Center in carrying out its threefold mission of (1) preparing recommendations for Federal ADP Standards, (2) assisting other agencies, and (3) conducting research and development. Because the Brooks bill (Public Law 89–306) charges the Bureau of the Budget, the General Services Administration, and the Department of Commerce with improving ADP utilization in Government, the services of TIE are used not only by the Center, but also by the BOB, the GSA, and other executive agencies.

The former NBS Information Technology Division, from which most of the Computer Center was formed in 1965, maintained an accumulation of technical data known as the "Division Library." The material it received was reviewed and circulated to interested members of the Division staff.

This loosely controlled collection and the more structured one of the NBS Research Information Center and Advisory Service on Information Processing (RICASIP) have been incorporated in the Technical Information Exchange, which was formally established as a division of the Computer Center by a Department of Commerce order in May 1966. In addition to its function as an information center, TIE was also named as a repository for source material for case histories and standardization efforts and was charged with assisting with special technical summaries and state-of-the-art reports.

Information Processing Reference Service

Since the primary purpose of TIE is to provide a reference service for information processing, much of the Exchange's present work is directed toward establishing an automated information storage and retrieval system for, and preparing the input information on, the existing corpus of information—some 1500 books and 60,000 documents—and the current input. The system currently produces by computer the following reference aids: A KWIC (*K*ey *W*ord *I*n *C*ontext) index, persona and corporate author indexes, a report number index, and a bibliographic citations listing.

The Exchange also constantly seeks additional sources of scientific and technical information for input to the system; this involves both retrospective searching and examining current state-of-the-art literature. Keeping up

to date on advances in computer research and technology serves several purposes: it identifies sources of information for the Exchange, extends staff capabilities, and keeps the corpus of information in the Exchange up to date. This awareness of current activities and technology is essential for providing technical advice and consultative services.

Reporting the State-of-the-Art

With the background provided by the constant input and evaluation of new information, the Exchange is well equipped to prepare critical reviews, state-of-the-art reports, and special bibliographies when these are needed. These reviews and reports are produced, as schedules and funding permit, not only to acquaint the Center's staff with recent technological advances and with research and development related to information processing problems, but also to inform the organizations and individual workers in the field. As a byproduct of this activity, the knowledge and expertise of the staff members who prepare the reviews and reports are enhanced and current awareness maintained.

Computer Sciences and Technology Index

TIE is also cooperating with the Center's Systems Research and Development Division to set up an automated index of current computer projects both within the Government and by its contractors. The TIE staff is now collecting and analyzing resumes of research and technology projects and developing a preliminary set of subject categories by which to group the projects by general subject area. Other members of the Center's staff are contributing specific competence in various areas of the computer field. This index is now in experimental operation.

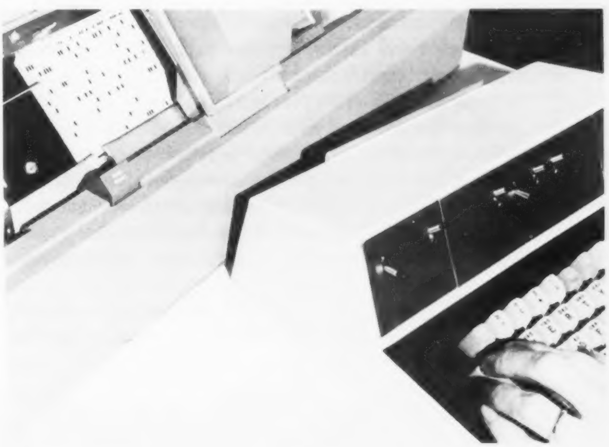
Program and Documentation Reference Service

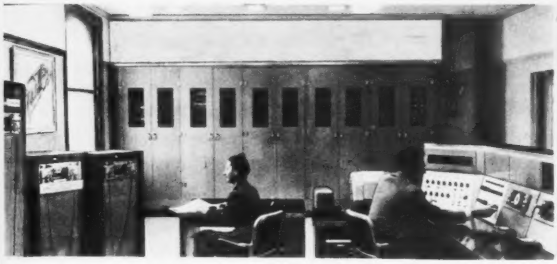
A TIE project now being started is intended to make it easier to benefit from computer programs that originate at numerous sources, both inside and outside of Government. Knowledge of new computer programs and their applications to date will encourage their wider use, thus leading to improvement in the cost-benefit effectiveness of computer systems.

The first step will be to establish a directory of those sources of computer programs which provide sharing services. The directory will be based on a survey of such sources, including computer user groups, Government agencies and their contractors, industrial organizations, universities, trade associations, and manufacturers of computer equipment. Subsequently data will be compiled on the usefulness of programs by means of appraisals of the documentation and records of use, on the effectiveness of program-sharing operations, and ultimately on the economics of program sharing.

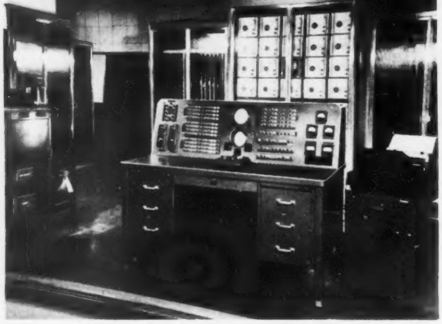
The directory will enable members of the Center's staff and information processing personnel of other agencies and in industry to ascertain the availability and usefulness for an existing application of computer programs already in existence. It should also increase the effectiveness of programmers by encouraging them to prepare full program documentation and to participate in program interchange.

*The **KWIC** (Key Word In Context) index program developed by NBS makes it easy to produce indexes for fast literature searching. The index is obtained by punching each entry on cards (l.); the cards are processed by a computer to produce a printout in which each entry appears once for each significant word contained in it. Thus,* Models in the Empirical Sciences *appears not only under* Empirical, *as shown (r.), but also under* Models *and* Sciences.

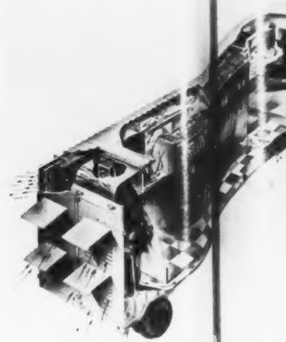




SEAC, Standards Eastern Automatic Computer, in 1954. Visible parts of SEAC are its circuitry (behind the doors, rear), tape memories (in cabinets, left), and operating console (right).



SWAC (Standards Western Automatic Computer), was built in 1950 by the NBS Institute for Numerical Analysis in Los Angeles. Behind the console is the Williams-tube memory bank and on the left are additional memory devices.



A HISTORY OF NBS COMPUTER DEVELOPMENTS

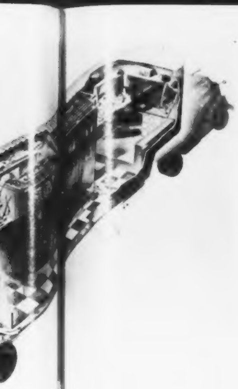
NBS man-machine simulation studies brought about the construction of this display console, which simulates an aircraft ground control center. It is paired with a simulated aircraft cockpit having an instrument panel and controls.

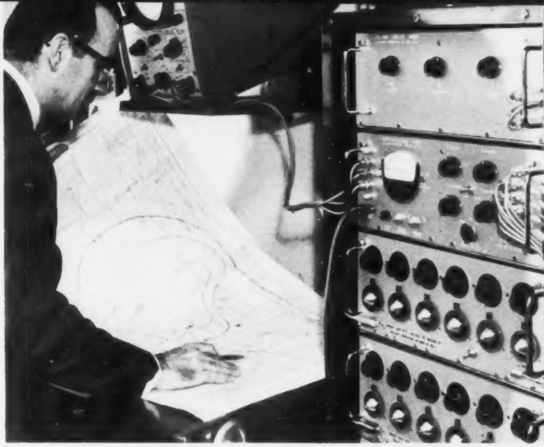
■ Much of the impetus for computer development has been military in origin, as when in the 1820's Charles Babbage, the father of the digital computer, was authorized by the British Government to make a computing machine for preparing ballistic tables. Based on Babbage's "difference engine," the device was intended to be accurate to 20 decimal places and was to cost 17,000 pounds, then an enormous sum. Unfortunately metalworking arts were not then sufficiently advanced to produce gears and linkages of the precision required and the project therefore foundered. Babbage was ahead of his time as a computer design genius, just as was Leonardo da Vinci in sketching helicopters long before they could be built.

The technological environment was entirely different in the late 1930's when Howard Aiken, a young graduate student at Harvard University, undertook the development of the first in a series of digital computers to serve scientific needs. He had available well-engineered components, such as electrical relays, in place of Babbage's gears and linkages. Aiken's first large-scale computer, the Automatic Sequence Controlled Calculator Mark I, went into operation in 1943 and soon was assisting Naval Ordnance in preparing ballistic tables.

To meet the growing need for massive computations resulting from the complexity of modern weapons, the Ordnance Department of the Army sponsored pioneering work on using the faster electron tube in place of the electrical relay for switching and storage. This work was directed by J. Presper Eckert and John W. Mauchly at the University of Pennsylvania and led in 1946 to the successful operation of the first electronic digital computer, the ENIAC (*E*lectronic *N*umerical *I*ntegrator *a*nd *C*alculator). While the ENIAC was too late for the war effort, it so increased speed and productivity that it was promptly applied to a variety of important military and scientific tasks.

At this time work on electronic computing machines began at NBS as part of the Bureau's program of technical assistance to other agencies. The potential of these machines was recognized to include not only solving in hours mathematical problems which could otherwise be solved only by crude approximations or thousands of





Among Bureau developments using both analog and digital techniques was this instrument for predicting fallout from a radioactive detonation of known position and intensity. Wind speed and direction at various altitudes are set into the instrument at lower right, and cloud characteristics above it. The oscilloscope shows the distribution of fallout, while the panel meter gives the machine's prediction for each point selected on the map.

ACCESS (Automatic Computer Controlled Electronic Scanning System) *was developed by NBS for the Office of Emergency Planning. The system was designed to scan microfilm and process data obtained from the film and remote sources for appraisals during a national emergency. From the left are a FOSDIC* (Film Optical Sensing Device for Input to Computers) *microfilm reader and viewing screen, the processing control panel, keyboard and punched tape inputs, and logic and memory components (background).*

man-days of calculations, but also the capability of handling, classifying, and analyzing data. Awareness of this potential interested Government agencies in obtaining computers; two of them asked NBS to provide the specifications and deal with the manufacturers. The Bureau contracted with Eckert and Mauchly's Electronic Control Co. for a UNIVAC for the Bureau of the Census and with Raytheon Corporation for the RAYDAC for the Office of Naval Research. These were the initial Government requirements which triggered the growth of the billion dollar market that developed within 20 years.

Meanwhile, in work sponsored by Army Ordnance, the Bureau was working on the development and engineering of computer components to improve their performance and reliability for use in Government-sponsored computer projects. The first efforts in this program were directed to the development of basic components, including memory organs, input and output equipment, and associated specialized electron tubes for use in such computing functions as gating, switching, delaying signals, interval timing, and pulse shaping.[1] One of the devices developed during this period was the magnetic wire cartridge, a simple input-output device that recorded on and read electrical pulses from magnetic wire. This simple device was utilized in all of the automatic electronic computing systems designed and developed by the Bureau—SEAC, SWAC, DYSEAC, and the Pilot Data Processor, as well as in two "cousins" of SEAC, FLAC and MIDAC.

In those early days the major responsibility for the Bureau's computer program was shared by its Ordnance Development Division and its National Applied Mathematics Laboratories. The former was responsible for soundness of engineering design, the latter for mathematical sufficiency of logical design. In 1947 the computer development group in the Ordnance Development Division was designated the Electronic Computer Section; later it became part of the Electronics Division. In the same year the group working on computer design in the National Applied Mathematics Laboratories was designated the Machine Development Laboratory.

It was at this time that difficulties encountered in obtaining a computer system for another agency significantly

continued

influenced the direction taken by NBS computer research. The Office of Air Comptroller of the Air Force had requested that an NBS contract be amended to include a UNIVAC for Air Force program planning applications under Project SCOOP (*S*cientific *C*omputation *o*f *O*ptimum *P*rograms). SCOOP was a pioneering effort to apply scientific principles to large-scale problems of military management and administration. When it became obvious that the solution of unexpected technical difficulties by the contractor would greatly delay delivery, the Air Force requested the Bureau to embark on a crash development program for a modest system, designated the NBS Interim Computer. The NBS Interim Computer, renamed SEAC (*S*tandards *E*astern *A*utomatic *C*omputer), went into productive operation in April 1950, just 20 months after its inception. It was then the fastest general-purpose, internally sequenced electronic computer in operation and provided the initial high-speed computing support to Project SCOOP until its UNIVAC was delivered in 1952. A third UNIVAC for the Army Map Service also was contracted for by the Bureau.

During this period another computer, to be known as SWAC (*S*tandards *W*estern *A*utomatic *C*omputer), was being built at the Institute for Numerical Analysis, a section of the NBS Applied Mathematics Division, at Los Angeles. Operative early in 1952, SWAC differed from SEAC in using a parallel mode of operation. Its primary memory was composed of Williams tube units (later experimented with in SEAC, also), enabling all digits of a number to be placed in memory or transferred simultaneously and arithmetic operations to be performed simultaneously.

The development of SWAC was jointly sponsored by the Air Force's Office of Air Research, out of interest in the machine itself, and by the Office of Naval Research, out of interest in programming and mathematical research. SWAC was used in the solution of many aircraft problems by several Federal agencies; it was ultimately turned over to the University of California at Los Angeles, where it remained in use for 15 years.

The Decade of Intensive Development

The 1950's were productive years for the Bureau's computer activities. From the beginning, these activities were typified by cooperation with other Government agencies in attempting to solve their problems expeditiously and effectively. These cooperative efforts were directed both to the analysis of potential applications and to the specification of appropriate systems for their achievement. This sometimes necessitated the development of specialized devices and techniques to meet unique needs within the Government. During this period the Bureau was also playing a highly effective role in speeding the new computer era

Plug-in circuitry for computers was developed early in the Bureau's computer research and has since been improved and repeatedly redesigned. In the background is an original SEAC signal-gating package in front of which is a plug-in version. Later generations of packages performing this function are arrayed to show their evolutionary relationship, with the most recent in the foreground. Partially opened is a package using flexible supports and conductors. Left of it are two contemporaneous modules characterized by use of connectors and wrap-around frames; one features printed circuitry. Its descendants include (foreground) modules making connections at conductive patterns on the printed circuit board, others continuing the frame-and-connector approach, and a single generation of a printed-circuit module using a different type of connector.

through programs of research and education. The fundamental research and training courses it conducted in numerical analysis led to the development of a text in this field.

The decade from 1950 to 1960 was notable for a series of technological developments and a milestone, the solution by SEAC of its first problem, a series of equations for tracing skew rays through an optical system, in April 1950. Important developments included the improvement of components, the first successful interconnection of two independent, large-scale computing systems (the SEAC and DYSEAC), and implementation of the concept of a computer for evaluating experimental approaches to new applications.

The experimental-approach computer, called the Pilot Data Processor, was an advanced system of three interconnected computers, designed to provide extremely useful flexibility and adaptability. This concept of a universal test bed for new applications was a sound one, but interface problems arose and there was a lack of ready access to sufficient memory capability. Meanwhile, the technological shift from vacuum tubes to solid-state devices and the expanding flexibility of systems produced by industry caused the Bureau to turn its attention to other areas of the computer sciences.

The traditional statutory mission of the Bureau to provide technical assistance to other Government agencies is exemplified by the many and diverse projects applying to or improving automatic information-processing techniques for solution of specific problems of other agencies.

A systematic review of NBS Annual Reports from 1946 to the present provides a remarkable overview of these activities. The completion, and successful operation, of SEAC and the near completion of SWAC are recorded in the 1950 Annual Report, as are the collateral and continuing investigations in standardized electronic circuit modules, studies of solid-state components as circuit elements, and solutions to electro-mechanical problems associated with the transport and rapid start-stop features of the Microfilm Rapid Selector, the magnetic tape-handling device, and the high-speed card punch.

Problems of computer input were also receiving attention. In the early 1950's the Bureau's Electronic Instrumentation Section designed and fabricated FOSDIC (*F*ilm *O*ptical *S*canning *D*evice for *I*nput to *C*omputers) for the Bureau of the Census, using optical, mechanical, and electronic techniques. This machine was used to read microfilm of hand-marked Census forms and to record the data obtained on magnetic tape for input to a computer. FOSDIC was so useful for scanning forms and graphic material that advanced and more flexible versions were later devised for the Bureau of the Census, the Weather Bureau, and the Office of Emergency Planning, for use in a variety of applications.

In 1954 SEAC was used for quick, accurate determination of low bidders on contracts let by the Army Quartermaster Corps. The high-speed computation methods used for this application resulted from a continuing program of research which the Bureau had been conducting for the Air Force in the mathematical theory of linear programming. This new mathematical field, in combination with electronic computation, made possible speed and accuracy previously unobtainable in the solution of many military supply and logistics problems. The bid evaluation work carried on by NBS at that time was one of the first instances in which extensive production computing services were performed by a computation facility for a remote customer linked to it by telephone circuits.

Soon the original computers were followed by logical descendants; one, the STATAC-SCOOP, was designed for the Air Force Comptroller's Office as an elaborate, high-speed serio-parallel successor to SEAC and UNIVAC. DYSEAC, the first full-scale transportable digital computer, was designed by NBS and used by the Signal Corps at White Sands, New Mexico. The MIDAC and FLAC systems, based on the SEAC and DYSEAC design, resulted from the collaboration of NBS with the University of Michigan's Willow Run Research Laboratory and the Air Force Missile Test Center.

Many new items of "hardware" were developed and tested at the Bureau during the early 1950's. Research on the problem of data storage led to the development of two prototype high-speed memory units, one using cathode ray tubes and the other diodes and capacitors as the storage units; a notched-disk memory device for high-density static storage; and a reelless magnetic tape-handling device for high-density recording. Other developments were packaged circuit units offering reduced size, low power requirements, and high reliability and a punched card sorter based on an endless belt with a coded cam arrangement for pocket selection. The possible use of solid-state components in place of vacuum tubes for computer switching and storage functions was of great interest to members of the Bureau staff at this time.

By mid-1954, numerical data were being processed on a large scale in the Federal agencies, and the Bureau responded to their concomitant needs by establishing the Data Processing Systems Division (formed from the Electronic Computers Section). One of its purposes was to provide an advisory center for Government on electronic computing and data processing techniques. The agencies which took advantage of these services are too numerous to be listed here, but several significant long-term programs are indicative of the extensive efforts. These include an investigation of the application of automatic electronic equipment to the processing of mail for the Post Office Department (since 1955), an investigation of the application of computers to patent search operations for the U.S. Patent Office (since 1956), and a research program in logical organization of components into systems with increased speed and data manipulation power, sponsored jointly by the Army's Aberdeen Proving Ground and NBS. A procedure utilizing a computer to convert system design plans into tables specifying point-to-point interconnections and other detailed construction data was also developed as an outgrowth of the Aberdeen-NBS activity.

Digital and analog techniques were combined at the Bureau to solve several unique problems, such as the development (for the Weather Bureau and the Atomic Energy Commission) of a special-purpose computer for predicting the radioactive fallout pattern for a 250-mile radius from the power and detonation point of a nuclear device. Analog-digital techniques were used also in the design and implementation of the prototype of a man-machine systems simulator for the Wright Air Development Center and the Federal Aviation Agency. NBS participation on the Airways Modernization Board, the precursor of the FAA, had provided impetus and insight for studying the factors involved in coupling a human being into a system composed of computers, display devices, and control equipment. The development of automated mail coding and sorting systems also had pointed up the need for human engineering experimentation to optimize the interaction between the affected personnel and the equipment.

Meanwhile the application of automatic data processing systems to management problems continued to expand into new areas; the processing of payroll and accounting data and supply management information became commonplace. NBS conducted a nationwide training program

continued

sponsored by the Air Force for its Air Materiel Command's middle management personnel in the late 1950's. This was the most comprehensive educational effort undertaken among the many technical advisory and consulting tasks performed at the request of other agencies.

The voluminous data required for most of these management applications accentuated the input problem and gave impetus to research efforts in automatic character recognition and pictorial data processing. Likewise, the development of special data logging systems to obviate the tedium of recording and preprocessing data within NBS laboratories was a direct result of the continuing concern over the input problem. The problems inherent in electromechanical devices such as the Microfilm Rapid Selector and the FOSDIC also were under study, with particular emphasis on start-stop features at higher speeds of operation.

The expansion of exploratory and exploitation activities in this new field of automatic data processing brought with it its own information explosion. The National Science Foundation (NSF) had been established in 1950 to foster the development of science; it was attempting to do this in large part through the diffusion of scientific knowledge. One of its concerns was naturally the collection and maintenance of a central reference file of information on the many research and development projects in universities, industry, and Government laboratories for improved techniques for automatic processing of scientific data and documentation. Thus in December 1958 a Research Information Center and Advisory Service on Information Processing was established at NBS, to be operated jointly by the Bureau and NSF. It was charged with maintaining current information on the research and development activities in the field, including entries for projects, researchers, and publications. In addition to providing advisory services on information processing and research, it also published reviews of programs as state-of-the-art reports and specialized bibliographies on selected subjects and has continued to perform such functions since its incorporation into the Center for Computer Sciences and Technology.

The 1960's—Years of Progress

The early 1960's led not only to further broadening of the Bureau's range of activities in the computer field, but also to the initial steps toward standardization in the dramatically expanding technology of information processing. For example, NBS participated in the establishment of two programmer-oriented computer languages, ALGOL for scientific applications and COBOL for business problems. As early as 1960, significant initial contributions were made toward standardization of symbols, languages, and equipment through participation in the activities of the American Standards Association (now USASI), under the sponsorship of the Business Equipment Manufacturers Association. In 1962, when the need for expansion of these activities became recognized, the ASA established an Information Processing Systems Standards Board, the first chairman of which was then Chief of the NBS Data Processing Systems Division.

Projects undertaken for other agencies were changing in nature during this period; typical of the new projects was the development of two special-purpose digital computers. One was the Automatic Meteorological Observation Station (AMOS IV), designed to serve as the central element of an automatic system to collect and process weather data for the Weather Bureau. The other was an Automatic Computer-Controlled Electronic Scanning System (ACCESS) for manipulation of information on resources and their status. Other projects at this time were a requirements study for, and design of, an automatic data-recording system for the Navy's Bureau of Supplies and Accounts; research on ways of scanning aerial stereophotographic information to derive elevation profiles; numerous feasibility studies, among them investigations of the applicability of automatic data-processing techniques to selected operations of the Federal Communications Commission, the Interstate Commerce Commission, and the Maritime Administration; the automatic collection of information on radiological hazards for the Public Health Service; development of more effective storage and retrieval techniques for the research grants program for the National Institutes of Health, the information dissemination functions of the Office of Technical Services, and drug data for the Food and Drug Administration; and an evaluation of the system requirements for maintaining an inventory of nonmilitary satellites for the National Aeronautics and Space Administration.

In 1963, the late President John F. Kennedy became convinced of the need for a comprehensive review of the Government's policies with respect to the acquisition and use of automatic data processing equipment. He directed the Bureau of the Budget to undertake such a survey, the results of which were submitted to President Lyndon B. Johnson by the Director of the Bureau of the Budget as a "Report to the President on the Management of Automatic Data Processing in the Federal Government." In early March 1965 the President referred the report to the 89th Congress and the Bureau of the Budget issued Circular A–71 which made the Department of Commerce (through NBS) responsible for aiding the executive agencies in achieving increased cost-effectiveness in the selection, acquisition, and utilization of automatic data processing equipment.

Public Law 89–306, which was enacted by the 89th Congress in October 1965, not only reaffirmed the statutory role of the Bureau to provide technical assistance to other Government agencies, but also made it responsible

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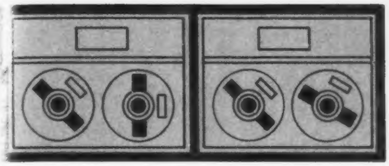


Information Processing

With this issue the Technical News Bulletin begins a new column which will attempt to meet the needs of the automatic-data-processing community for an up-to-date newsletter on developments in the ADP Standards field. This column will emphasize work directed at ADP standardization in Government and, in particular, the activities of the NBS Center for Computer Sciences and Technology.

The GSA Role in Federal ADP Management

■ The Brooks bill (passed by the Congress in 1966 as Public Law 89–306) assigned important responsibilities for managing Federal procurement and utilization of computers to the General Services Administration, along with the Bureau of the Budget and the Department of Commerce (see page 151). GSA's previous data-processing coordination work was placed under the GSA's Federal Supply Service in August 1966. Known as the Office of Automated Data Management Services (OADMS), it is headed by E. D. Dwyer, Acting Assistant Commissioner of the FSS.

The OADMS plans, directs, and coordinates all the GSA's efforts in the procurement, utilization, and management of ADP and related equipment within the Government. It coordinates the GSA's efforts with those of other Federal agencies, Congressional committees, industrial associations, and firms. It is planning centralized data-processing services for Federal agencies that do not have their own facilities or which need additional capacity to meet unusual workload demands.

GSA Activities

From time to time this column will report GSA activities that are of general interest. The first of such items follows.

Centralized Testing and Cleaning of Magnetic Tape: The Federal Supply Service has recommended that procurement testing and cleaning of tape now in inventory be centralized. This recommendation has been accepted and is being put into operation. It is expected to save the Government an estimated $8,000,000 annually.

Support Sharing: Sharing unused computer time is now commonplace. Recently the GSA has extended sharing, in an arrangement between the Small Business Administration and the National Aeronautics and Space Administration, to systems analysis and programming support for economic research projects.

Long-Term Sharing Benefits: Sharing is usually done in order to meet short-term requirements for equipment time to accommodate peak workloads and one-time demands. Recently, however, the GSA arranged for the Navy to share in the use of a Federal Communications Commission computer system in Boston for 18 months and thereby avoid buying a system of its own.

ADP Management Information System: The GSA plans to produce an inventory of ADP in the Government, called the ADP Management Information System (MIS), which is expected to make for better management. Agencies having ADP facilities were asked to supply the MIS with briefs describing their systems by June of this year.

International Voluntary Standards

Standardization at the international level of the codes, characters, languages, recording media, and data transmission variables is desirable to achieve the greatest versatility and effectiveness of computer systems, to speed research, and to facilitate marketing of ADP components. International standards are being developed, and their voluntary acceptance encouraged by several international standards groups: The International Organization for Standardization (ISO), its affiliate the International Electrotechnical Commission (IEC), the International Telecommunications Union (ITU) and such of its subsidiaries as the International Telegraph and Telephone Consultative Committee, the European Computer Manufacturers Association, the Pan-American Standards Committee, and the American-British-Canadian Conference on Unification of Engineering Standards.

Two of the ISO technical committees promulgating standards affecting information processing are the Computers and Information Processing Committee (TC97) and the Office Machines Committee (TC95). The eight subcommittees and a new working group of TC97, are as follows:

SC1 Vocabulary
SC2 Character Sets and Coding
SC3 Character Recognition
SC4 Digital Input-Output Media
SC5 Programming Languages
SC6 Digital Data Transmission
SC7 Problem Definition and Analysis
SC8 Numerical Control of Machine Tools
WGK Data Codes and Elements

continued

INFORMATION PROCESSING *continued*

USASI X3 Subcommittees

The United States of America Standards Institute (USASI) coordinates much of the voluntary standards work in the United States and, at the international level, with the International Organization for Standardization.

The USASI Committee X3 is the Sectional Committee for Computers and Information Processing charged with forwarding standardization of ADP devices, equipment, and systems. This Committee consists of 36 members, divided equally among general interest, consumer, and producer groups. It is divided into the following subcommittees:

- X3.1 Optical Character Recognition
- X3.2 Codes and Input-Output
- X3.3 Data Transmission
- X3.4 Common Programming Languages
- X3.5 Vocabulary
- X3.6 Problem Definition and Analysis
- X3.7 Magnetic Ink Character Recognition
- X3.8 Data Elements and their Coded Representation

The X3 Committee and subcommittees of the American Standards Association (from which USASI was formed on September 1, 1966) had produced a total of 17 voluntary standards. Since then USASI X3 has approved two new standards, one for USASI One-Inch Perforated Paper Tape for Computers (X3.18–1967) and $^{11}/_{16}$-Inch Perforated Paper Tape for Computers (X3.19–1967).

STANDARDS AND CALIBRATION

IMPROVED CALIBRATION ACCURACY FOR MICROWAVE BOLOMETRIC DEVICES

The calibration accuracy for microwave bolometric devices has been improved significantly by the NBS Radio Standards Laboratory in Boulder, Colo. What usually is called the "dc—rf substitution error" of bolometer units, heretofore has been the largest single source of uncertainty in calibration. Recent experimental and theoretical studies have reduced the limits of this error for the Radio Standards Laboratory (RSL) microwave power standards to ± 0.25 percent instead of the former ± 1 percent.

The RSL working standards are barretter-type waveguide bolometer units in which both d-c power and microwave power are dissipated in a very fine platinum wire. However, the temperature distribution produced by microwave power differs from that produced by d-c power, and this gives rise to the substitution error.

This work permits improved measurement accuracy for bolometer units and bolometer-coupler units calibrated for other laboratories. The overall uncertainty in the measurement of effective efficiency of waveguide barretter-type bolometer units in the frequency range 3.95 to 8.2 GHz is now ± 0.75 percent instead of ± 1.5 percent. A similar improvement in accuracy is available for the measurement of effective efficiency of thermistor-type bolometer units, the measurement of calibration factor of thermistor- and barretter-type bolometer units, and the calibration factor of bolometer-coupler units. The frequency range covered includes two waveguide sizes, WR137 (3.95 to 5.85 GHz) and WR187 (5.85 to 8.2 GHz). Power calibrations usually are performed at a nominal power value of 10 milliwatts.

STANDARD FREQUENCY AND TIME BROADCASTS

WWV—2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz
WWVH—2.5, 5.0, 10.0, and 15.0 MHz
WWVB—60 kHz

Radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast signals that are kept in close agreement with the UT2 scale by making step adjustments of 100 ms as necessary. Each pulse indicates that the earth has rotated approximately 15 arcseconds about its axis since the previous one. Adjustments are made at 0000 UT on the first day of a month. *There will be no adjustment made on 1 September 1967.* The pulses occur at intervals that are longer than one second by 300 parts in 10^{10} due to an offset in carrier frequency coordinated by the Bureau International de l'Heure (BIH), Paris, France.

Radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses derived from the NBS Time Standard (NBS-III) with no offset. Step adjustments of 200 ms are made at 0000 UT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be an adjustment made on 1 September 1967. The seconds pulses emitted from WWVB will be retarded 200 ms.*

Floyd Mauer checks the position of the table bearing a small crystal sample as the NBS modular datalogging system (right) records the crystal's diffraction pattern. Servomotors rotate the crystal on three axes to orientations assigned by punches on the paper tape in the foreground. The diffraction data for successive positions are automatically punched on another tape.

SPECIALIZED COMPUTATIONAL EQUIPMENT FROM GENERAL-PURPOSE MODULES

■ The measurement automation program at the Center for Computer Sciences and Technology has demonstrated that most of the special-purpose automatic data-recording systems needed by NBS laboratories can be built from a relatively small number of module types. The system requirements are divided into specific functions to be performed; modules which perform these functions are assembled into the instrumentation system. The modules were developed at the Center, using a family of NBS-designed, solid-state printed-circuit cards, and are carried in stock for incorporation in instrumentation being assembled.[1] This consists, in the simplest case, of mounting the necessary modules in a rack, programming them, interconnecting them, and connecting the system to the data source.

Modular construction has minimized the problem of equipment obsolescence, since the modules can be easily updated and the equipment can be modified to satisfy changing requirements. Other advantages of modular construction are a reduction in engineering costs, a reduction in construction time, and the ability to reuse modules returned from no-longer-needed systems.

Machine-collected data are not only more accurate (being less subject to errors in reading, writing, or transscribing) and more conveniently obtained, but make possible experiments that could not otherwise be undertaken. This includes experiments that produce data too fast, too infrequently, too irregularly, or over too long a period of time to be taken by a laboratory staff. The modular systems assembled at the Computer Center not only record data at rates of up to 50 datum points per second, but can also be programmed to control experimental parameters, such as voltage and wavelength. The data obtained are recorded on a medium—usually magnetic or paper tape—that can be read directly into the computer that subsequently processes the data.

Each of the modules developed at the Center contains its own power supply and for use requires only line power, signal inputs, and programming. The circuitry is transistorized and is laid out on printed circuit cards offering ease of maintenance and good spatial efficiency. The standard module types are: Programmable control, scanner and multiplexer, analog-to-digital converter, counter, register, and output interface. Most systems are assembled from these modules and commercial tape-reading and tape-encoding units that mount in the same way; some applications also require the use of a specially designed module or two.

Modular Systems in Use

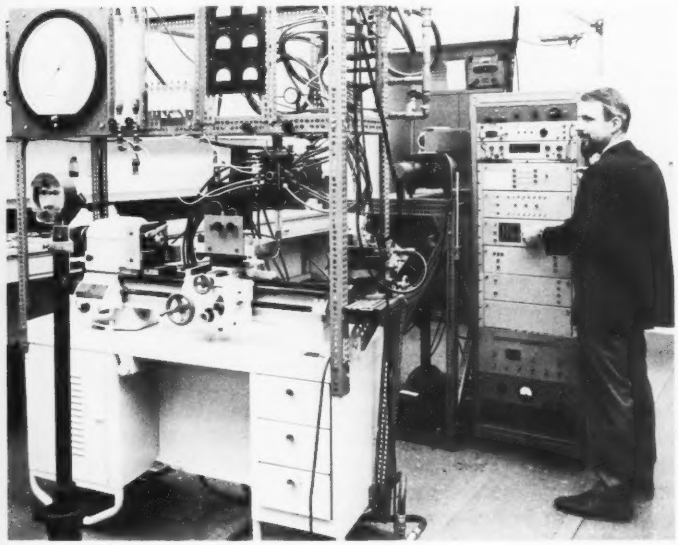
Many special-purpose modular systems have been designed and assembled at the Computer Center for use elsewhere at the Bureau and in the laboratories of other Government agencies. One such unit is a computer-controlled calibrator, which is used in instrumentation for geophysical data collection at Table Mountain, Colo., to calibrate the phase and amplitude response of the receivers automatically.

Another example is the instrumentation package assembled for the Bureau's crystallography laboratories to assist in studies of crystal structure by means of an x-ray diffractometer. This instrument orients a sample of the material under study in an x-ray beam and measures the intensity of the diffracted beam. A single measurement may require from 30 seconds to 15 minutes and data for several thousand predetermined sample settings may be necessary. Such runs take days or even weeks to complete.

continued

MODULES *continued*

By eliminating the need for an operator to make the angle settings and transcribe the data, the automated system makes possible around-the-clock operation with increased speed and accuracy. This was accomplished by adding a punched paper tape reader, teletypewriter control module, memory, and programmer to an existing semiautomatic diffractor. The system differs from others in that it has been designed to operate both by reading a punched paper tape prepared by a computer (off-line control), or by a direct link with a remote computer over a telephone line (on-line control). In the latter case, one of the existing teletypewriter channels is to be used so that no special interface will be required.



The intensity distribution across a plasma arc in a chamber (to which many tubes run) is measured by this equipment. Charles Popenoe is putting a computational system, assembled from the Bureau's standard instrumentation modules, into operation to process and record data. The chamber is moved by the lathe carriage so that the image of the arc sweeps across the entrance slit of the monochromator (rear, beside the module cabinet). The intensity of the light passed by the monochromator is sensed by a photomultiplier and recorded automatically on paper tape.

Another laboratory use of a system assembled from the modules is a datalogger for studies of wall-stabilized plasma arcs. It consists of an analog-to-digital converter and the following modules: Shift register, interface module, supervisory control module, and paper tape punch.

This experiment requires that the intensity of the plasma be recorded for a succession of positions across the cylindrically confined plasma for each wavelength of interest. To do this, the plasma generator is mounted on a surface which is mechanically moved across the field of view of a monochromator and returned for each scan cycle. The datalogger records on the punched tape the intensity of light at one wavelength as a function of distance across the plasma. Then the monochromator is set to the next wavelength desired while the movable carriage returns to its beginning position; the scanning process is repeated for each subsequent wavelength desired. The data resulting, a series of intensity-position plots for the series of wavelengths of interest, is then processed by a computer.

Still another laboratory application for the Bureau's general-purpose modules has been in a data converter for off-line use. It converts digital data encoded in punches on paper tape to digital data encoded on magnetic tape, using commercial tape transports for two of its modules, a punched paper-tape reader, and a digital stepping recorder for magnetic tape. The circuitry is composed of the following modules in a cabinet: Programming patchboard, a ripple/shift register, an interface module which drives the magnetic tape recorder, a supervisory control module, and a special-purpose control module. A keyboard permits data to be encoded on the magnetic tape manually, also.

This data converter cannot only transfer data from the perforated paper tape to the magnetic tape, but can also process each character before it is recorded on the magnetic tape. This includes such operations as dividing an 8-bit character into two 4-bit ones and converting from an 8-level input to a 7-level one.

[1] **Transistorized modules for datalogging systems,** NBS Tech. News Bull. **50,** 42–43 (Mar. 1966).

OPTICAL CHARACTER *continued*

and a machine-readable lower case. Because of close association with those engaged in writing standards, NBS staff members are prepared to interpret these standards to any user or supplier who may have doubts about the meaning of terms or specifications.

The background of technical knowledge gained in these standardization activities makes it possible for the Center to offer technical assistance to Federal agencies that use OCR equipment or contemplate using it. Both the laboratory and computation facilities of the Center are available for this purpose. In addition, the establishment of an OCR service center as part of the Center for Computer Sciences and Technology is being considered. Such a service center would perform an important function in doing work on OCR problems and programs for Federal agencies that do not yet have OCR equipment.

NSRDS NEWS

This column regularly reports significant developments in the program of the National Standard Reference Data System. The NSRDS was established in 1963 by the President's Office of Science and Technology to make critically evaluated data in the physical sciences available to science and technology on a national basis. The System is administered and coordinated by the National Bureau of Standards through the NBS Office of Standard Reference Data, located in the Administration Building at the NBS Gaithersburg Laboratories.

Information and Data Centers Associated With the National Bureau of Standards Office of Standard Reference Data

This month *NSRDS News* identifies the present network of information and data centers associated with the NBS Office of Standard Reference Data. The centers are listed alphabetically. (Centers without addresses are located at NBS, Washington, D.C. 20234.)

1. ALLOY DATA CENTER, NBS Institute for Materials Research
   Director: L. H. Bennett
   Field covered: Physical properties of metals and (primarily binary) alloys.
   Purpose of activity: To compile critically evaluated data on physical properties of metals and alloys.
2. ATOMIC ENERGY LEVELS DATA AND INFORMATION CENTER, NBS Institute for Basic Standards
   Director: V. M. Sitterly
   Field covered: Atomic spectra and atomic energy levels, for both neutral and ionic species.
   Purpose of activity: To provide: critical appraisal of data on atomic spectra; identification of spectral transitions and establishment of atomic energy levels; a central reference source for energy level data; coordination of experimental work in the laboratories working in this field.
3. ATOMIC & MOLECULAR PROCESSES INFORMATION CENTER, Oak Ridge National Laboratories, P.O. Y, Oak Ridge, Tenn. 37831
   Director: C. F. Barnett
   Field covered: Heavy particle-heavy particle interactions, particle interactions with electric and magnetic fields, particle penetration into macroscopic matter.
   Purpose of activity: To evaluate data critically and publish results in the form of reviews; to perform literature searches.
4. ATOMIC TRANSITION PROBABILITIES DATA CENTER, NBS Institute for Basic Standards
   Director: W. L. Wiese
   Field covered: Radiative transition probabilities of atoms and atomic ions in the gas phase.
   Purpose of activity: Collection, evaluation, and publication of data on atomic transition probabilities. Response to inquiries from the public.
5. BINARY METAL AND METALLOID CONSTITUTION DATA CENTER, Illinois Institute of Technology, Chicago, Ill. 60616
   Director: N. M. Parikh
   Field covered: Primarily binary combinations of metallic elements excluding binaries with halogens and those that are not metal related (e.g., C–H, C–O, H–O).
   Purpose of activity: To prepare reviews of published constitution data similar to the work initiated by M. Hansen in *Constitution of Binary Alloys.*
6. DATA CENTER FOR BINARY OXIDES, NBS Institute for Materials Research
   Director: R. S. Roth
   Field covered: Condensed phase diagrams of 59 oxides of 70 elements or 1711 systems which are solids at 25 °C.
   Purpose of activity: Critical analysis of binary metal oxide systems.
7. CHEMICAL KINETICS INFORMATION CENTER, NBS Institute for Basic Standards
   Director: D. Garvin
   Field covered: Rates of homogeneous chemical reactions in gas, liquid, and solid phases; photochemistry, inelastic scattering.
   Purpose of activity: Bibliographic support for NSRDS "critical review" series in chemical kinetics. Information center.
8. CHEMICAL THERMODYNAMICS DATA GROUP, NBS Institute for Basic Standards
   Director: D. D. Wagman
   Field covered: Thermochemical and thermophysical

continued

properties of chemical substances in gas, liquid, and solid phases.
Purpose of activity: To provide self-consistent tables of "best" values of enthalpy and Gibbs free energy of formation, entropy, heat capacity and phase-change properties for chemical compounds.

9. CRYOGENICS DATA CENTER, National Bureau of Standards, Boulder, Colo. 80301
Director: V. J. Johnson
Field covered: Low-temperature data on properties of materials.
Purpose of activity: To acquire and catalog for bibliographic purposes all literature and data of interest in cryogenics, and to evaluate and compile low-temperature data on properties of materials.

10. CRYSTAL DATA CENTER, NBS Institute for Materials Research
J. D. H. Donnay, Chief Editor (Johns Hopkins University); H. M. Ondik, NBS Editor; V. Kennard, Organic Editor (Cambridge University).
Field covered: Crystallographic data on all solids; data and related information on unit cell dimension of crystal materials.
Purpose of activity: To revise and bring up to date the volume of *Crystal Data*; to maintain this semi-critical compilation; to identify crystalline materials by single crystals; and to collect and maintain data and information on crystalline materials.

11. DIATOMIC MOLECULE SPECTRA AND ENERGY LEVELS DATA CENTER, NBS Institute for Basic Standards
Director: A. M. Bass
Field covered: Optical spectroscopic data and constants for diatomic molecules (all pertinent regions of the electromagnetic spectrum are covered); molecular parameters derived from spectroscopic measurements.
Purpose of activity: To establish a single source of information in the field covered; to compile tables and evaluate data, e.g., band-heads, spectral frequencies, molecular energy levels and parameters, dissociation energies.

12. CENTER FOR DIFFUSION IN GASES, University of Maryland, College Park, Md.
Director: J. M. Marchello
Field covered: Diffusivity and viscosity in gas, liquid, solid, and turbulent fluid systems.
Purpose of activity: Compilation and critical evaluation of transport data.

13. DIFFUSION IN METALS AND ALLOYS DATA CENTER, NBS Institute for Materials Research
Director: J. R. Manning
Field covered: Diffusion properties of metals and alloys.
Purpose of activity: To compile and critically evaluate data on the diffusion in metals and alloys.

14. FUSED SALTS DATA CENTER, Rensselaer Polytechnic Institute, Troy, N.Y. 12181
Director: G. Janz
Field covered: Molten salt data on the conductance, viscosity, density, emf, and surface tensions of inorganic compounds as single-salt melts.
Purpose of activity: Critical evaluation of data.

15. HIGH PRESSURE DATA CENTER, Brigham Young University, Provo, Utah 84601
Director: H. T. Hall
Field covered: Compressibility of solids.
Purpose of activity: To review and critically evaluate experimental data on properties of materials at high pressures. Current emphasis is on the pressure scale and calibration.

16. HIGH TEMPERATURE BEHAVIOR OF INORGANIC SALTS, NBS Institute for Basic Standards
Director: K. H. Stern
Field covered: Thermodynamic properties, thermodynamics, and rates of decomposition of inorganic salts with monatomic cations and well defined oxyanions (sulfates, carbonates, nitrogen-oxygen and halogen-oxygen anions).
Purpose of activity: Critical evaluation of properties of inorganic salts.

17. JOINT INSTITUTE FOR LABORATORY ASTROPHYSICS INFORMATION CENTER, Joint Institute for Laboratory Astrophysics, University of Colorado, Boulder, Colo. 80302
Director: L. J. Kieffer
Field covered: Collisions between electrons, photons, ions, atoms, and molecules of astrophysical interest.
Purpose of activity: Compilation and critical reviews of data on collisions between electrons, photons, ions, atoms, and molecules.

18. LIGHT SCATTERING DATA CENTER, Clarkson College of Technology, Potsdam, N.Y. 13676
Director: J. Kratohvil
Field covered: Light scattering in gases, liquids, and liquid mixtures; refractive index increments in liquids and solutions.
Purpose of activity: Collection and evaluation of data in the area of light scattering.

19. LOW TEMPERATURE SPECIFIC HEATS DATA CENTER, NBS Institute for Basic Standards
Director: G. Furukawa
Field covered: Low temperature specific heats (0–300

°K) for the elements and oxides: low temperature calorimetry and related topics.
Purpose of activity: Evaluation of low temperature specific heat data with emphasis on cases where precision is high and which are suitable for theoretical work.

20. MASS SPECTROMETRY DATA CENTER, NBS Institute for Basic Standards
Director: H. M. Rosenstock
Field covered: Ionization and appearance potentials, by all techniques, including spectroscopic and theoretical ion molecule reactions.
Purpose of activity: To develop a reliable body of information and data on fundamental molecular properties and processes measured by mass spectrometric techniques; to furnish data in convenient tabular form on ionization and appearance potentials and heats of formation of ionic species.

21. MICROWAVE SPECTRA DATA CENTER, NBS Institute for Basic Standards
Director: D. R. Lide
Field covered: Microwave spectra of molecules and the physical properties derived therefrom (rotational constants, etc.).
Purpose of activity: Publication of tabulations of evaluated microwave absorption lines.

22. PHOTONUCLEAR DATA CENTER, NBS Institute for Basic Standards
Director: E. G. Fuller
Field covered: Interaction of electro-magnetic radiation with nuclei.
Purpose of activity: To provide best available data on photonuclear reactions and photonuclear cross sections and related quantities.

23. RADIATION CHEMISTRY DATA CENTER, University of Notre Dame, Notre Dame, Ind. 46556
Director: M. Burton
Field covered: All substances, organic and inorganic; aqueous and non-aqueous solutions; solids, gases. Radiation yields; kinetic data and physical properties on radiation.
Purpose of activity: To collect and compile data from chemical reactions brought about by ionizing radiation.

24. PROPERTIES OF ELECTROLYTE SOLUTIONS DATA CENTER, NBS Institute for Basic Standards
Director: W. Hamer
Field covered: Thermodynamics and transport properties of electrolyte solutions, both aqueous and non-aqueous: standard electromotive forces, electrode potentials, activity coefficients; electrolytic conductivities; transference numbers; ionic mobilities.
Purpose of activity: To establish reliable values for the thermodynamic properties of important electrolyte solutions.

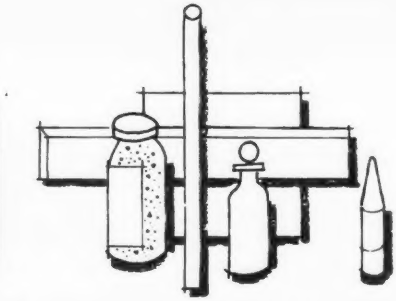
25. SUPERCONDUCTIVE MATERIALS DATA CENTER, General Electric Research and Development Center, Schenectady, N.Y. 12301
Director: B. W. Roberts
Field covered: Superconductive materials
Purpose of activity: To collect, collate, and disseminate information on superconductive materials and to evolve standard values of important parameters for these materials.

26. THERMODYNAMICS RESEARCH CENTER, Department of Chemistry, Texas A&M University, College Station, Tex. 77840
Director: B. J. Zwolinski
Field covered: Organic compounds of interest to science technology with emphasis on hydrocarbons and certain organic oxygen, nitrogen, sulfur, and halogen compounds.
Purpose of activity: To conduct extensive literature search, experimental and theoretical research, selection, and correlation of data related to physical, thermodynamic, and spectral properties of organic compounds.

27. THERMOPHYSICAL PROPERTIES RESEARCH CENTER, Purdue University, 2595 Yeager Road, West Lafayette, Ind. 47906
Director: Y. S. Touloukian
Field covered: Coefficient of expansion, viscosity, thermal conductivity, thermal diffusivity, diffusion coefficient (mass), specific heat, thermal radiative properties, Prandtl number.
Purpose of activity: To provide authoritative and comprehensive source information on the thermophysical properties of all matter covering the world literature; to provide reference data based on integrated programs of critical evaluation of existing data, theoretical studies, and experimental determinations; to conduct basic and applied research on thermophysical properties of materials.

28. X-RAY ATTENUATION COEFFICIENT INFORMATION CENTER, NBS Institute for Basic Standards
Director: J. H. Hubbell
Field covered: Attenuation coefficients for high energy photon (x-ray, gamma-ray) interaction with matter, including Compton and Rayleigh scattering, atomic photoeffect and electron-position pair production.
Purpose of activity: Evaluation and dissemination of photon cross sections and attenuation coefficients.

STANDARD REFERENCE MATERIALS



The NBS Office of Standard Reference Materials has prepared three new carbon dioxide-in-nitrogen standard reference materials, and renewals of natural rubber and six metallo-organic compounds. This provides for continued availability of these well-characterized materials for calibration of measurements in science and technology. These standards, along with more than 600 others, are available to government and industry to facilitate the exchange of goods, to strengthen quality control, and to help determine performance characteristics.[1]

CARBON DIOXIDE IN NITROGEN

The long-term increase in the carbon dioxide content of the atmosphere has been recognized for some time. The level has risen from about 290 ppm to about 325 ppm in the last 50 years and is rising at about 1 ppm per year; industrial and agricultural activities may be accelerating this increase. Carbon dioxide appears to be the one contaminant of the atmosphere for which there is long-term accumulation—an accumulation that may be counteracted at times by the amounts withdrawn by the oceans, by rocks, and by living organisms.

To study the rate and magnitude of the change, the Weather Bureau and other groups have established measuring stations for simultaneous data gathering at many different points around the world extending from Point Barrow, Alaska, to the South Pole. While the primary purpose of this work is to establish the mean background levels upon which further changes due to atmospheric pollutants may be superimposed, it is also possible that the data will contribute to increased knowledge of the chemistry of air pollution and the dependence of mean air temperature and climate on the carbon dioxide content of the atmosphere. It has been postulated for more than a century that carbon dioxide in the atmosphere controls temperature through its absorption in the infrared region which prevents energy from escaping from the earth into space—the well-known "greenhouse effect."

For simultaneous data collection and monitoring of carbon dioxide levels at different, widely separated, geographic locations, samples must be taken continuously or at intervals over a long period of time and measurements of concentration must be closely tied to a standard.

Very precise measurements may be made by determining the deviation from a base line. Standard materials for this work may be prepared by statistically intercomparing a number of cylinders of prepared gas. However, this method does not prevent a long-term drift of the base line. The NBS carbon dioxide-in-nitrogen standards were developed to calibrate the working gases and to monitor a long-term drift in concentration.

The new Standard Reference Materials are NBS Nos. 1601, 1602, and 1603, having carbon dioxide concentrations of 0.0308 ± .0003, 0.0346 ± .0003, and 0.0384 ± .0004 mole percent respectively in nitrogen. They were prepared by successively diluting mixtures of carbon dioxide in nitrogen containing high concentrations of carbon dioxide.

The original gas mixture and each subsequent mixture were analyzed for carbon dioxide both by a gravimetric method and by a mass spectrometric technique developed specifically for this analysis.[2] They were also evaluated over a period of time to detect possible changes in composition with time, or with changes in pressure of storage conditions.

The carbon dioxide-in-nitrogen standards are supplied in disposable cylinder units. The cylinders are filled to approximately 500 psi and contain about 68 liters of gas when measured under standard conditions. The price for these standards, not yet established, will be published in the Federal Register.

These standards were prepared by the NBS Analytical Chemistry Division, Institute for Materials Research. Preparation and analyses were made by E. E. Hughes and W. D. Dorko.

STANDARD METALLO-ORGANIC COMPOUNDS

The amount of wear and the probability of failure of an internal combustion engine may be determined by analyzing its lubricating oil for metals. Such analysis is done with the optical emission spectrometer. Because accurate predictions ordinarily are made on the basis of trends in data accumulated over a period of time from a series of determinations, it is necessary to have standard reference materials for calibrating the apparatus. These standards must be stable, oil-soluble to the concentrations needed, and must not absorb an excessive amount of water. They should yield solutions in lubricating oil which are constant and which will not precipitate on standing.

A series of metallo-organic standards were developed at

the request of the Division of Refining of the American Petroleum Institute. At first, the principal users of the metallo-organic standards were the railroad and trucking industries. Here the analysis for metals in lubricating oils was used as the basis for maintenance schedules and predictions of equipment failure. Agencies of the Department of Defense also utilize the metallo-organics for safeguarding equipment and for minimizing maintenance and repair costs. Newer uses include monitoring the presence of catalyst metals and catalyst poisons in process streams.

Renewals of metallo-organic standards for determination of metals in petroleum products are: NBS Nos. 1059b lead cyclohexanebutyrate; 1078a, tris(1-phenyl-1,3-butanediono)chromium(III); 1079a, tris(1-phenyl-1,3-butanediono)iron(III); 1074a, calcium 2-ethylhexanoate; 1080, bis(1-phenyl-1,3-butanediono)copper(II); and 1073b, zinc cyclohexanebutyrate. These were prepared and certified to fill the need for an adequate collection of standards which could be used to prepare a desired blend of known metal concentration in any appropriate lubricating oil.[3]

The standards are supplied in units of approximately 5 grams at $15 per unit.[4] The certificate furnished with each gives the amount of the metallic element of interest that is present, and also directions for preparing a solution of known concentration in lubricating oil.

STANDARD NATURAL RUBBER

Rubber, a major commodity in international trade, is produced from raw materials that vary widely. To form rubber compounds and produce end-goods of uniform properties, it is necessary that the compounding procedures be related to a set of recognized standards with established known values. Such standards can be used as controls for calculating and appraising more nearly the true values for the material being tested, whether it is an elastomer, carbon black, or any other material used in compounding the rubber.

The Nation's rubber industry coordinates its needs for standard reference materials through a Special Advisory Committee representing both the American Society for Testing and Materials Committee D–11 (Rubber and Rubber-like materials) and D–24 (Carbon Black) and, through these, with the International Standards Organization. Availability of high-quality standards is essential to these endeavors.

Natural rubber is one of the standard reference materials for rubber compounding. NBS No. 385b, a renewal of the natural rubber standard, replaces No. 385a, the supply of which has been exhausted for some time. The renewal standard was evaluated by G. E. Decker, G. W. Bullman, and A. M. Brown of the NBS Institute for Applied Technology.

This renewal standard has been prepared from carefully blended lots of natural rubber latex coagulated in batches the same day as collected and characterized for different properties in accordance with appropriate ASTM procedures. NBS No. 385b is sold with an accompanying certificate which gives values for: stress at 100 and 600 percent elongation, and at failure; elongation at failure; strain at 5 kg/cm^2; and viscometer cure (including Mooney viscosity values at 125 °C). The certificate also gives details of the evaluation procedures used to establish these values.

[1] For a complete list of Standard Reference Materials available from NBS, see **Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards**, NBS Misc. Publ. 260, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 45 cents. Quarterly insert sheets which up-date Misc. Publ. 260 are supplied on request.

[2] A brief description of the mass spectrometric technique is given in NBS Technical Note 403 **Microchemical Analysis Section: Summary of Activities, July 1965 to June 1966,** edited by John K. Taylor. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 50 cents.

[3] Analytical Standards for Trace Elements in Petroleum Products, NBS Mono. 54 (1962). Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 25 cents.

[4] These standards may be purchased for the price indicated from the Office of Standard Reference Materials, National Bureau of Standards, Washington, D.C. 20234.

HISTORY *continued*

for an executive branch program in support of establishing voluntary commercial standards. This program would also improve compatibility within the Government by recommending uniform Federal standards for ADP equipment and techniques and for computer languages and by undertaking the necessary research.

In September 1965, Department of Commerce Order 90 formally established the Center for Computer Sciences and Technology, within the Bureau's Institute for Applied Technology, as the organizational unit responsible for acting on these responsibilities; it combined the staffs of the former Information Technology Division and the Computation Laboratory for its nucleus and was divided into Bureau divisions in May 1966. The most significant addition to the Center's organizational structure at that time, the Office for Information Processing Standards, reflects its new role in the development and recommendation of Federal automatic data processing standards.

[1] Annual Report of the National Bureau of Standards 1946, p. 202. Additional background information can be found in the subsequent Annual Reports of the National Bureau of Standards, the most recent one (for 1966) of which can be obtained as NBS Misc. Publ. 283 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 60 cents.

EXPLORATORY RESEARCH IN INFORMATION PROCESSING AT NBS

■ Progress in technology is closely linked to the advancement of knowledge through research in science and engineering. This coupling is especially close in the field of information processing, where a broad basis of exploratory research has produced the fastest growing technology in the world today.

Projects in applied research in the Center for Computer Sciences and Technology (CCST) range from theoretical investigations of mathematical models of information processing to finding solutions for novel, pragmatic problems. This research program not only generates results useful in themselves, it also helps to maintain an expert technical staff in the Center able to provide sound advice and consultation for the effective utilization of computers. In an area of such rapid expansion, where diverse applications are involved, it is impossible to support research in all areas of the computer sciences. The CCST therefore concentrates on generic problems that have widespread, general importance, and on specific problems that have a broad range of application. A knowledge of the state of the art is important for facilitating meaningful work in any area of research. State-of-the-art surveys are compiled and issued in order to identify promising areas for fruitful research and to support the research efforts resident in the Center.

Some examples of current research projects in the CCST are discussed in the following sections.

Two-Dimensional Linguistics

Computers can read information which is arranged in linear sequence and which can readily be reduced to the binary form used inside digital computers, but there is no ready facility for reading two-dimensional information such as diagrams, maps, and pictures. There are, however, some interesting new developments in the area of computer graphics—both in hardware and software—centered mainly around the use of visual display units. Some applications in this area are computer-aided design and representation of pictorial information in general.

Since 1962, the Center has carried on a continuing effort in linguistic analysis of two-dimensional sources of information. By far the largest part of the effort has been directed toward the analysis of Chinese characters, though there have been occasional, preliminary experiments with other two-dimensional sources. The research on Chinese characters has resulted in a number of formal treatments which explicate the formation process underlying well-formed Chinese characters.

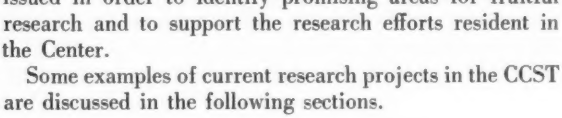
The research on Chinese characters begins with the assumption that the set of all well-formed Chinese characters can be viewed as a language in a fashion analogous to the way English and ALGOL, for example, are viewed as languages. The latter languages are made up of sets of symbol strings linearly concatenated from alphabets characteristic of these languages. Grammars for the languages seek to generate all the well-formed strings on the alphabets and none of the ill-formed strings on the alphabets. Chinese characters are viewed as being two-dimensional arrays formed from an alphabet of small character components in a non-linear fashion. Grammars for this "language" are based on the successful discovery of its alphabet, which is not nearly so obvious as in English, and its rules for two-dimensional combination. They seek to generate all of the well-formed Chinese characters on the alphabet and no ill-formed characters.

Currently research continues on precise characterization of the forms of grammars for Chinese characters, and on actual grammar construction. Also underway is a study of existing grammars for other two-dimensional sources of information with the aim of an eventual contribution toward a general theory of two-dimensional linguistics. This theory would contribute to the solution of the problem of general two-dimensional information processing.

Data Base Management

The production of computer equipment has outpaced the supply of technical and professional personnel required for its use. There is thus a demand for user-oriented software that will enable non-technical people to communicate directly with the computer in a medium resembling natural language.

An example of such user aids is a Selective Information Extractor (SIE) and report generator recently designed at the Center. Many data banks now exist in some kind of mechanized store; they usually contain a variety of data



Analysis of the formation of the Chinese character for "black."

elements. Users of the data banks generally require the selection of certain combinations of data elements and their arrangement and printout in the form of reports. The needs for particular data elements and for report formats change with time. With the SIE system, however, it is not necessary to write new computer programs to meet each different report requirement from the data bank. A simple language is required to express users' needs; design of the language structure had to precede design of the SIE system itself. The user will thus be able to employ SIE by describing his requirements in a simple, English-like, non-rigorous manner.

Science Information Handling Techniques

A well-known phenomenon of this age is the huge, ever-growing mass of scientific and technical information with which scientists and engineers must deal. The problem of finding needed facts among this diffuse mass is becoming increasingly difficult and its solution increasingly important.

Few, if any, areas have seen as explosive a growth in scientific information as chemistry. The Bureau has been active since 1956 in developing techniques for handling chemical information, cooperating at various times with other Government agencies such as the U.S. Patent Office, the Army Research Office, the National Science Foundation, and the National Institutes of Health. The research into chemical information handling techniques in the Center has been directed not at establishing a general chemical information center at NBS but rather at developing the techniques needed by these and other Government agencies.

The principal factor that makes easy access to information so difficult to achieve is the impossibility of predicting with much certainty all the types of questions that an information service will have to satisfy in the future. A high degree of flexibility is therefore a very desirable characteristic of an information system. The needed flexibility requires three interrelated capabilities: accurate and precise rendition of the information to be stored, efficient organization of the information, and effective search of the information. The specific means for representing information must be suitably adapted to its particular type. The accompanying figure indicates some of the many different types of information that may be associated with a single substance. The information shown here is only a very small portion of all the detailed information available about the substance. According to its type, information may be represented by words, numbers, special codes, or two-dimensional diagrams.

Another NBS study developed computer techniques for conducting searches on such notations for structures containing particular chemical substructures. For example, all compounds containing an acetate moiety have notations containing either the symbol string "OCVM," as here, or else "MCVO." An important aspect of this search technique is that it is possible to find structures containing acetate (or dimethylamino or sulphonamide or other) moieties without having to decide beforehand what moieties are present or which ones should be recorded. This power differs sharply from that of information systems which require each item to be indexed according to concepts considered important at the time the item is added to the system.

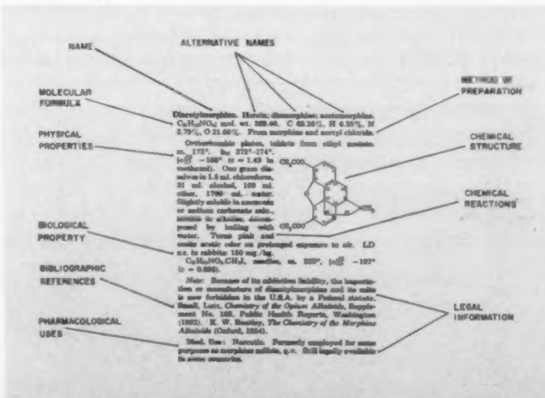
A program has been developed for automatic conversion of linear chemical notations into connection tables, a form that contains the chemical structure information in a listing somewhat analogous to "The thigh bone's connected to the hip bone. The hip bone's connected to the leg bone. The leg bone's connected to . . ." This detailed listing of individual atoms and their interconnections is closely comparable to the formats adopted by workers elsewhere.

A particularly challenging problem has been the manipulation within computers of the two-dimensional structural diagrams that are the basis of much of the communication among chemists. One possibility is to treat these diagrams essentially like television pictures, to be reproduced when needed. More productive has been the rendition of the information conveyed by the diagram into another form, much as the problem, "If Jane has five apples and Bill has four apples . . .," can be rendered as "J=5, B=4, . . ." The structure diagram of diacetylmorphine can thus be rendered as 6L(OCVM)L=LYλ5(LLNM*[1])L[1]LYλ5RRR(OCVM)Y5OY. Such strings of symbols can be readily entered into computers, arranged in lists, and searched. A study by the National Bureau of Standards and the U.S. Patent Office showed that people with very little chemical knowledge can routinely produce such notations.

A variety of different formats for representing the same information may be particularly useful for differing applications. Automatic conversion from one format to another

continued

Item from the Merck Index (p. 333, 7th ed., 1960, Merck & Co., Rahway, N.J.) showing the many different types of information associated with a single chemical substance; in this case diacetylmorphine, or heroin.



permits separate groups of workers to use those formats particularly well suited to their several purposes, yet to communicate intelligibly with one another.

A chemical file such as will satisfy the needs of even a single Government agency is likely not only to be very large, but also to contain a great variety of information. Not all of this information would interest any one part of the agency, and different individuals will place different emphasis even on the same general information. Consequently it is important to be able to select, from the larger file, subfiles of entries with special desired characteristics and to rearrange the entries in various ways for particular emphasis. One major aim of present NBS work is to devise a means for organizing information files in such a fashion that entirely new concepts can be accommodated without starting again from the beginning.

The entire orientation of the work on handling chemical and related information is toward computer manipulations. This does not, however, imply that everything must or should be done by computer. Included among the aims is the computer-aided production of information retrieval aids for use at a desk. Special-purpose compilations are an example of custom-tailored tools which would be a natural output from a system such as that for which the Computer Center is devising techniques.

Geophysical Data Collection

An important area of the computer sciences is the mechanization of data collection at the data source. Information is gathered automatically and is transcribed onto a computer-compatible medium. In many cases it is advantageous to include some data-reduction or data-processing functions in the equipment located at the data source. The system may be used at the same time to play an active role in control of the operation of the source equipment.

NBS, in cooperation with the Environmental Science Services Administration, conducts a data-collection operation of this sort. A large experimental station, located near Boulder, Colo., is collecting data on naturally occurring geophysical phenomena resulting from ionospheric or other disturbances. Automatic data-collection equipment designed at NBS is operating at this site in conjunction with a small on-line digital computer.

The data are collected from 10 basic sensor types, operating at frequencies ranging from infrasonic to optical. Some of them, such as the infrasonic systems, operate independently. Incoming signals are processed in an analog correlator and then recorded digitally on magnetic tape. Other sensors' outputs are filtered by digital means in the computer before being recorded. Some sensor outputs are simply digitized and stored with no processing. The computer is also used to generate data displays and graphs for human analysis. The optical sensor outputs are recorded photographically and are processed manually. These pictures may eventually be added to the automatically processed data inputs by means of optical scanning devices.

Magnetic tape records produced by these techniques are brought to a large, general-purpose computer for correlation and further processing. Thus, the responsibility for data reduction is divided in such a way as to optimize the total use of the analog equipment, the small on-line machine, and the batch-processing service facility.

This station represents an excellent opportunity for experimentation in all phases of source data automation, and such research is indeed one objective of the program. Results from these studies will further the understanding of our geophysical environment and will also improve our ability to solve source data automation problems generally.

MOBIDIC, originally a Mobile *(van-mounted)* Digital Computer, *is the keystone of the experimental computer facility at the Center for Computer Sciences and Technology. It will be used experimentally with remote stations and with different types of inputs. Tape transports for data input and output are on both sides of the console, and cabinets containing the semiconductor circuitry behind it. Tom Pyke, Jr., uses the terminal switching console to connect MOBIDIC to process data from a terminal (similar to the one in the foreground) in one of the Bureau laboratories.*

The experimental computer facility of the Center for Computer Sciences and Technology now uses a disk memory for some types of data storage. Louis Boezi is sliding a magnetic read-write assembly into place atop the magnetic disks of the memory.

CONFERENCE & PUBLICATION *Briefs*

NBS HOST TO ACM SYMPOSIUM

The Bureau was host on May 18, 1967, to the Sixth Annual Technical Symposium of the Association for Computing Machinery. The Symposium, which had as its theme "The Case for the Maligned Machine," was presented by ACM's Washington, D.C. Chapter under Symposium General Chairman G. Richard Reed (Department of the Navy).

Although computer technology has advanced far beyond its capabilities of a decade ago, its present performance is sometimes compared unfavorably with overoptimistic expectations of the past. Occasional computer errors now attract more widespread attention from the public than does the growth of the spectrum of applications in which computers are successfully used. The Association's concern about public distrust of computers was evidenced in the content of some of the Symposium's sessions.

The Symposium was opened with greetings from its General Chairman and a welcome to NBS delivered by John P. Eberhard, Director of the NBS Institute for Applied Technology. In the keynote address following, Carl Hammer (UNIVAC) asked if "computers are getting out of hand" and noted that the inadequacies of programming may bring discredit to the machine. In the session following, Hugh Donaghue (Control Data Corp.) presided over a panel composed of representatives of four computer manufacturers. Each of the panelists described a recent significant advance in computer technology.

The following session, chaired by Alec Bumsted (System Development Corp.) was devoted to computer "software." It featured a description of the growing use of source data systems in the U.S. Post Office, a discussion of the readiness to blame system programmers for problems resulting from unreasonable requirements imposed on the programmers, and a description of the need for more display-oriented software in present applications. The next session was presided over by Jack Moshman (EBS Management Consultants, Inc.); its discussion of computer "brainware" centered on computer programs for simulations and analyses.

The fourth session—"Forum on Foibles"—consisted of a panel under Moderator Peter Warburton (Control Data Corp.) which expressed concern about the practice of ascribing anthropomorphic qualities to computers and the feeling of some people that they are being victimized by computers. Reasons for these problems were discussed and some solutions proposed.

The final session was comprised of papers, delivered under the chairmanship of Walter Simonson (C-E-I-R, Inc.), about the needs of computer systems. The papers touched on such things as libraries of "standard" programs, the "single-document" approach to programming documentation, selecting good programmers, and how to use blind persons on a computer staff.

NBS SPONSORS SYMPOSIUM ON COMPUTER-AIDED TYPESETTING

Almost 600 people from 25 states and two foreign countries, interested in the field of computer-aided typesetting, converged on the new installation of the National Bureau of Standards in Gaithersburg, Md., on June 15 to take part in the two-day "Symposium on Electronic Composition in Printing." The Symposium was sponsored by the NBS Center for Computer Sciences and Technology to permit a state-of-the-art review of a rapidly advancing field of computer application which has great potentialities for increased efficiency and savings in the Federal Government.

The state-of-the-art of photocomposition was well covered by representatives from the major manufacturers of photocomposing machinery. Participating companies included: Mergenthaler Linotype Co., Bell Telephone Laboratories, Photon, Inc., A. B. Dick Co., Fairchild Graphic Equipment, RCA, Stromberg-Carlson, and IBM. The policy of the Government concerning the new technology was made clear by J. L. Harrison, the Public Printer of the United States, and by J. F. Haley, the Staff Director of the Congressional Joint Committee on Printing.

Several papers were presented by representatives from research and printing and publishing organizations including Documentation, Inc., Photo Data, Inc., and American Chemical Society, all of Washington, D.C.; and by Battelle Memorial Institute of Columbus, Ohio, and ROCAPPI, Inc. of Swarthmore, Pa.

Papers describing specific applications of the computer in typesetting were presented by representatives from the Air Force; the Government Printing Office; the Department of Health, Education, and Welfare; National Library of Medicine; U.S. Patent Office; Defense Supply Agency; and the National Bureau of Standards.

Session chairmen included Lowell P. Hattery of American University, Paul A. Ziemer of the Department of Commerce, Glenn E. Roudabush of the University of Pittsburgh, and Samuel N. Alexander and Mary E. Stevens of NBS. The Symposium committee consisted of Richard W. H. Lee, Roy W. Worral, and W. R. Tilley of NBS.

The proceedings will be published in the near future and will be available from the Superintendent of Documents, U.S. Government Printing Office.

continued

Left: Honorable James L. Harrison, the Public Printer of the United States, tells the attendees of the "new look" at the Government Printing Office. Right: John P. Eberhard, Director of the NBS Institute for Applied Technology, welcomes the Symposium participants to the Bureau.

BRIEFS *continued*

OUTLINE OF PROGRAM

Session I State of the Art

Overview
Lowell P. Hattery
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The Linotron System
Donald H. Rollert
Mergenthaler Linotype Co.

Computer Image Drawing from Digital Data
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Bell Telephone Laboratories

High Speed 901 Zip
Anthony G. Bernardo
Photon, Inc.

The Videograph Text Editor
Glendon T. Gerlach
A. B. Dick Co.

The PhotoTextSetters
A. J. Smith
Fairchild Graphic Equipment

A Videocomp Systems Approach
Aaron H. Coleman
RCA

Micromation—Its Impact on the Photocomposing Industry
J. J. Kalagher
Stromberg-Carlson

IBM's Position in Electronic Composition and Text Editing
Hans E. Weiss
IBM

Session II Government Policy

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U.S. Department of Commerce

Transition on the Tiber—A New Look at the G.P.O.
Honorable James L. Harrison
The Public Printer of the United States

Present and Projected Policies of the J.C.P.
John F. Haley
Congressional Joint Committee on Printing

Session III Non-Government Applications and Research

Introductory Remarks
Glenn E. Roudabush
University of Pittsburgh

Chemical Information—A Computer in Photocomposition
Bernard G. Lazorchak
American Chemical Society

The Import of Computerized Typesetting on Commercial Printing
William C. Lamparter
Battelle Memorial Institute

Computerized Typesetting Projections
Kenneth B. Ludwig
Photo Data, Inc.

Classification in Computerized Text Processing
Raymond P. Wishner
Documentation, Inc.

System 70
John W. Seybold
ROCAPPI, Inc.

Session IV Government Applications

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Samuel N. Alexander
National Bureau of Standards

Electronic Composition within the Department of Health, Education, and Welfare
E. Ray Lannon
Food and Drug Administration, HEW

Electronic Composing System Applications
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U.S. Government Printing Office

Use of GRACE at N.L.M.
Ronald E. Bogart
National Library of Medicine

Computer Typesetting Program at NBS
William R. Bozman
National Bureau of Standards

Typewriter-to-Computer Roster Publication and Maintenance
Arthur North
U.S. Patent Office
(Now with Documentation, Inc.)

Implications of Electronic Composition System at DSA Publications
William J. Beran
Defense Supply Agency

Conversion to Linotron
Victor G. Kehler
Department of the Air Force

ACHIEVING COMPATABILITY *continued*

and a number of additional changes were also made in order to conform to the ISO 7-bit code.

In early 1966, before the December 1965 version of ASCII was in print, consideration was being given to holding the previously mentioned joint meeting of ISO Subcommittee 2 and the CCITT Working Party. The USA group (Subcommittee X3.2) was therefore faced with the prospect of a second revision to ASCII, if it wished to try for certain revisions in the ISO 7-bit code that would be particularly advantageous to the United States. The decision was made to undertake the revision.

Agreement between ISO and CCITT was reached in April of 1966 and a second revision of ASCII was subsequently undertaken. Approval of this second revision of the USA Standard Code for Information Interchange, X3.4–1967, now known by its USA Standards Institute title, USASCII, should be completed in the near future.

With international agreement established, the code standardization work is now entering a period of stability. Work is underway to establish the 7-bit code as a national standard in most of the European countries participating in the ISO Subcommittee 2 project.

Media standards work implementing the 7-bit code in perforated tape, magnetic tape, and punched cards is also underway at both the national and international level. This work is most advanced in perforated tape. A USA Standard Perforated Tape Code for Information Interchange, X3.6–1965, was approved in July 1965. A vote is now being taken on a proposed equivalent standard in ISO Technical Committee 97.

Starting in October 1965, the NBS Center for Computer Sciences and Technology, acting for the Department of Commerce, in cooperation with the General Services Administration, surveyed the information processing and communications equipment suppliers as well as the Federal Departments and independent agencies relative to adopting the USASCII as a Federal standard. This study recently culminated in a recommendation by the Secretary of Commerce to the Director of the Budget Bureau that the USASCII be adopted as a Federal Standard.

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

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Journal of Research of the National Bureau of Standards
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Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $2.75; foreign, $3.50. Single copy, 75 cents.

CURRENT ISSUES OF THE JOURNAL OF RESEARCH

J. Res. NBS **71A** (*Phys. and Chem.*), No. 4 (July–Aug. 1967).

Kinetics of crystallization in multicomponent systems: I. Binary mixtures of n-paraffins. J. I. Lauritzen, Jr., E. Passaglia, and E. A. DiMarzio.

Kinetics of crystallization in multicomponent systems: II. Chain-folded polymer crystals. J. I. Lauritzen, Jr., and E. Passaglia.

Infrared absorption spectra of 2-oxo-1, 3-bis (phenylhydrazono) derivatives and related bis- and tris-phenylhydrazones. A. J. Fatiadi.

Dielectric constant of n-hexane as a function of temperature, pressure, and density. F. I. Mopsik.

Heat capacities and related thermal data for diethyl phthalate crystal, glass, and liquid to 360 °K. S. S. Chang, J. A. Horman, and A. B. Bestul.

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Poincaré's conjecture is implied by a conjecture on free groups. R. D. Traub.

Construction of EPr generalized inverses by inversion of nonsingular matrices. J. Z. Hearon.

A generalized matrix version of Rennie's inequality. J. Z. Hearon.

Polar factorization of a matrix. J. Z. Hearon.

Two classical theorems on commuting matrices. M. Newman.

A converse to Banach's contraction theorem. P. R. Meyers.

E-transforms (II). F. M. Ragab.

Criterion for the stability of numerical integration methods for the solution of systems of differential equations. A. I. Abdel Karim.

Discrete complex functions with prescribed boundary values and residues. E. L. Peterson.

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Procedure for high precision density determinations by hydrostatic weighing. H. A. Bowman and R. M. Schoonover with Appendix by M. W. Jones.

Study of the storage stability of the barium fluoride film electric hygrometer element. F. E. Jones.

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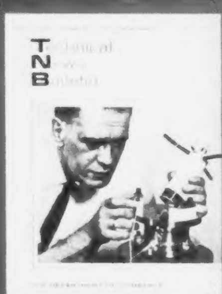

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